

## DONORS

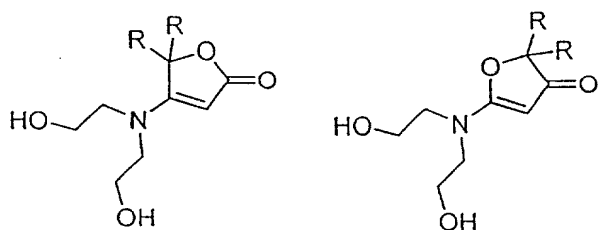
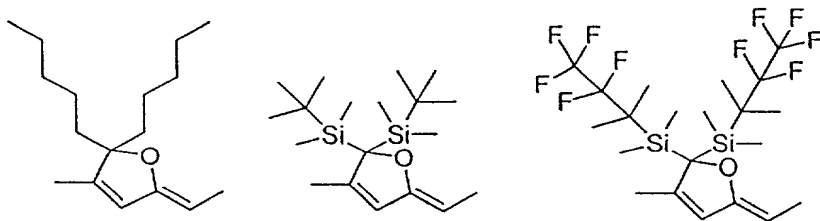


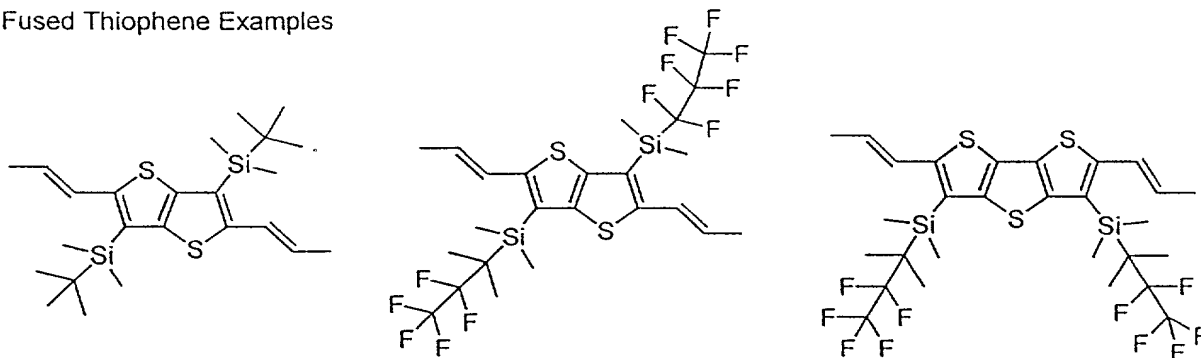
FIGURE 1

## BRIDGES

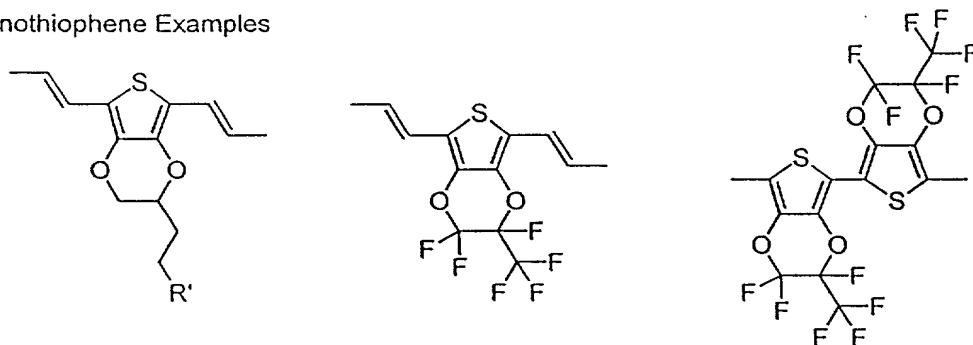
### 1. Polyene Examples



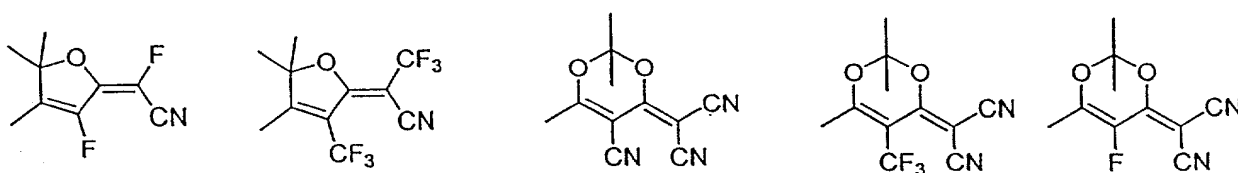
### 2. Fused Thiophene Examples



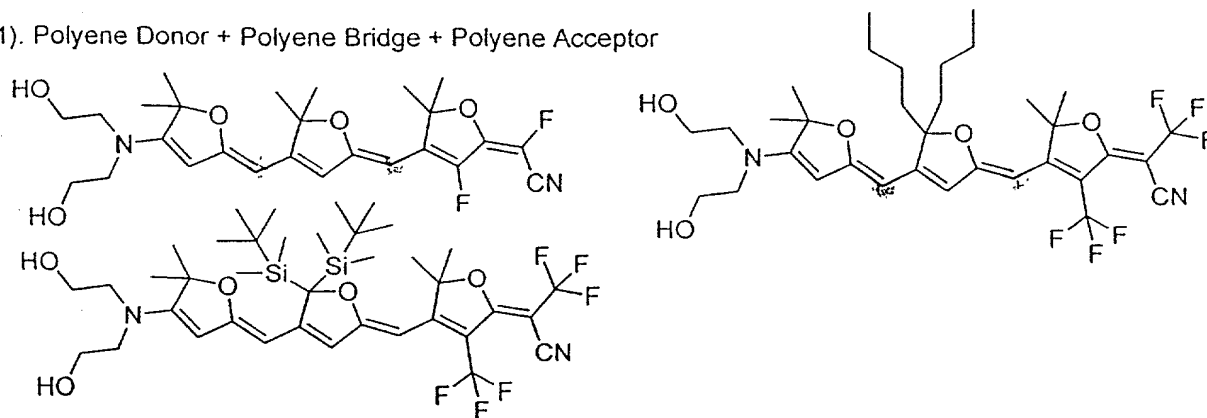
### 3. Monothiophene Examples



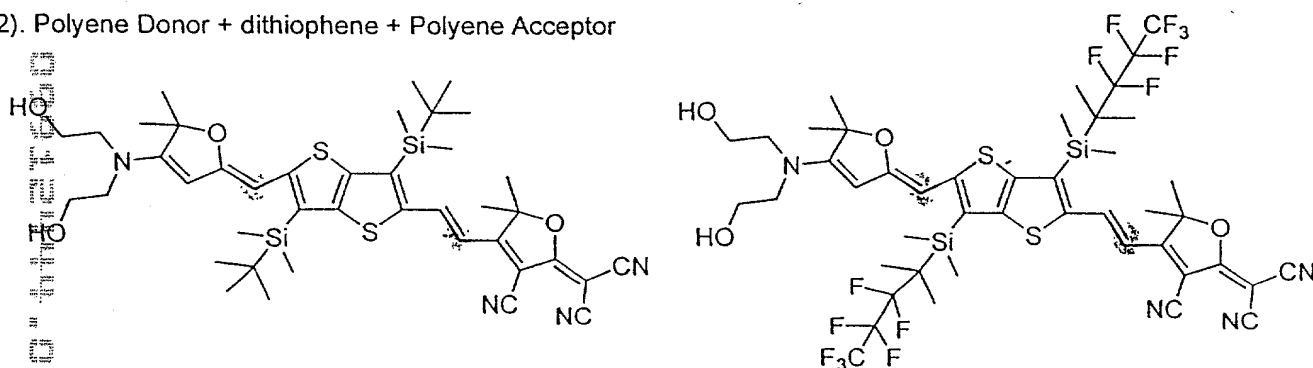
## ACCEPTORS



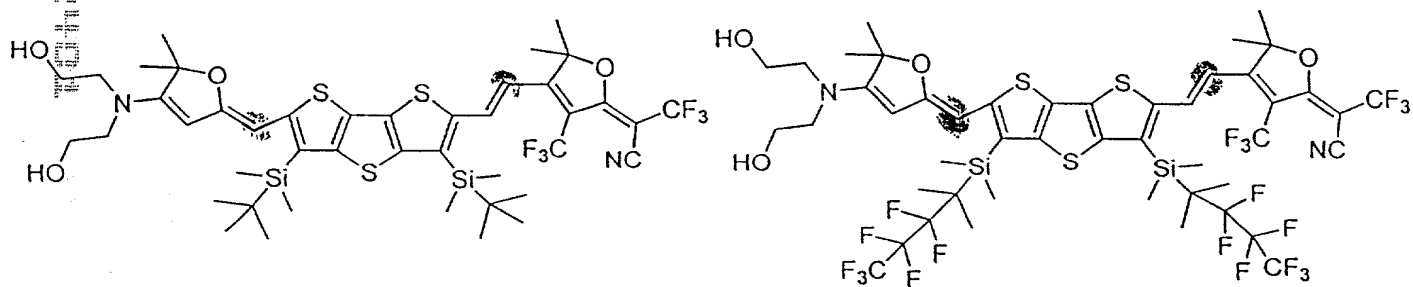
1). Polyene Donor + Polyene Bridge + Polyene Acceptor



2). Polyene Donor + dithiophene + Polyene Acceptor



3). Polyene Donor + tri-thiophene bridge + Polyene Acceptor



4). polyene Donor + thiophene + Polyene Acceptor

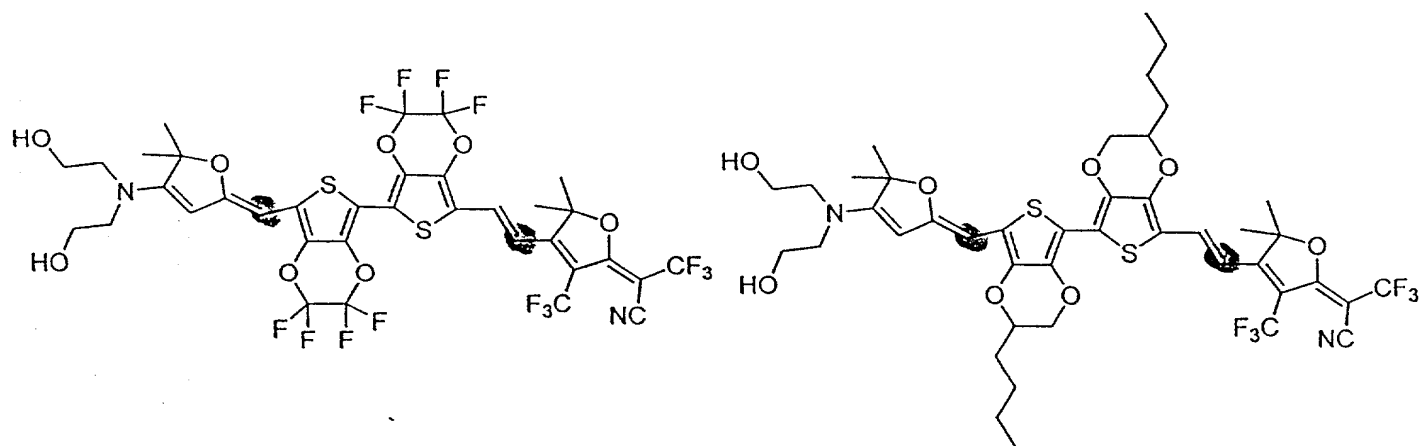


FIGURE 2

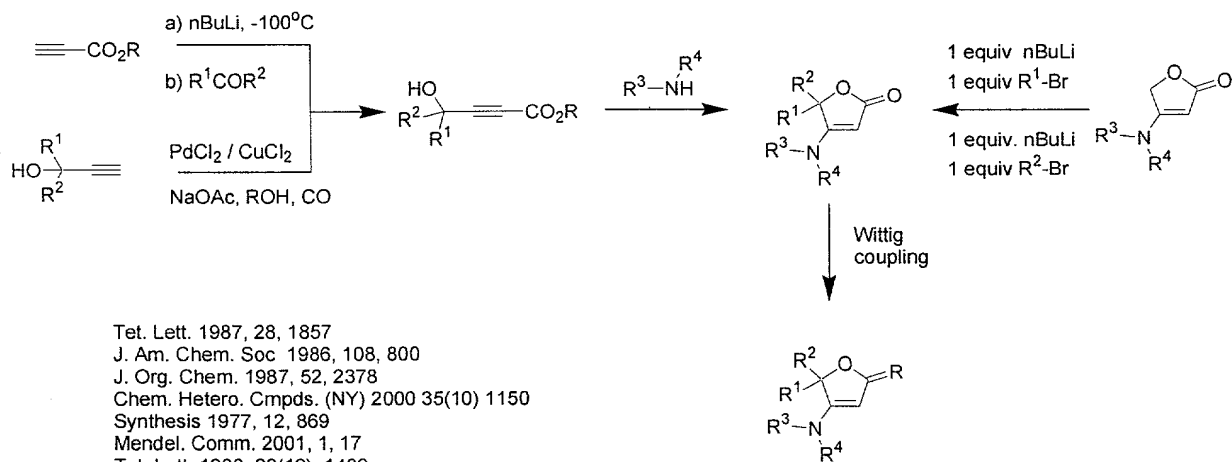
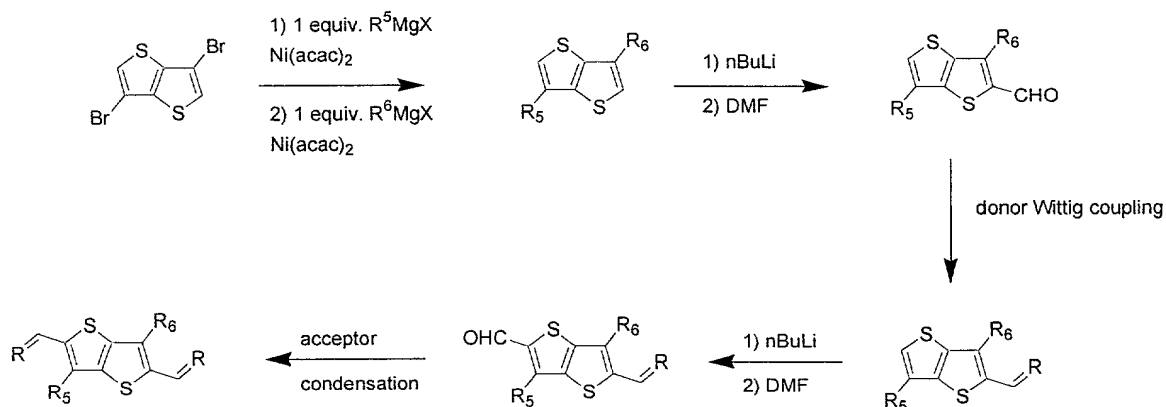


FIGURE 3



J. Chem. Soc. Perk. Trans. 1 1997, 22, 3465

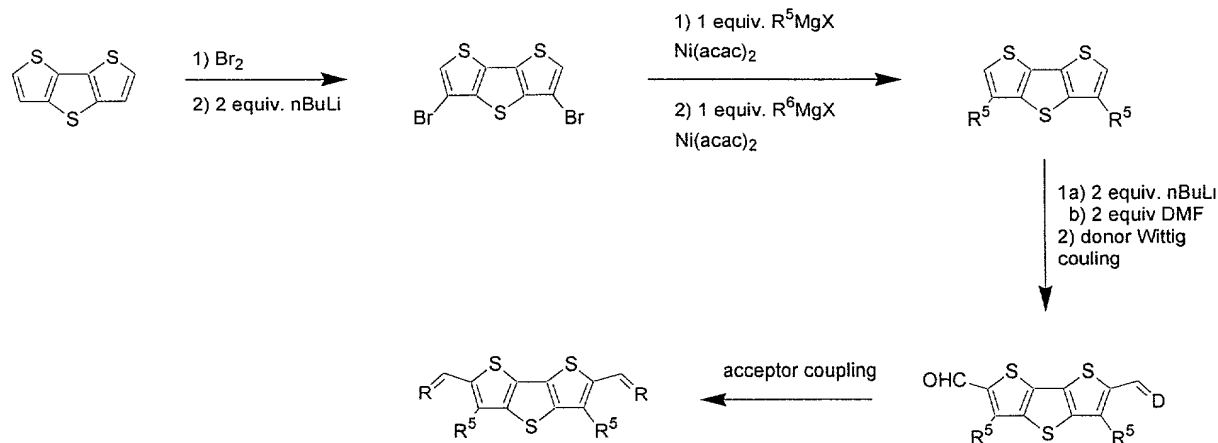
Heterocycles 1994, 38(1), 143

J. Organomet. Chem. 1973, 50, C12

Pure Appl. Chem. 1980, 52, 669

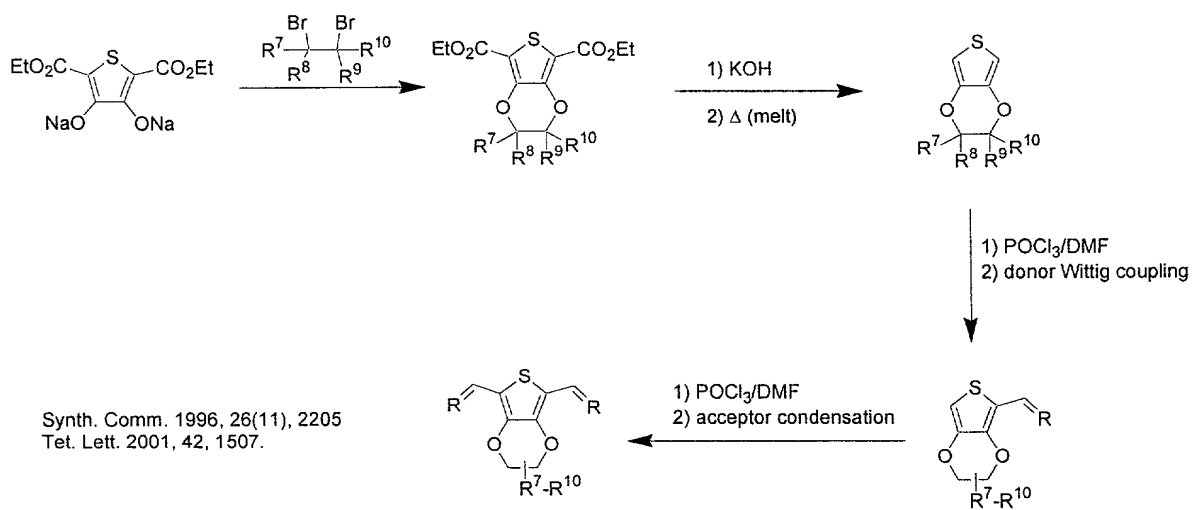
Tet. Lett. 1981, 22, 4449

FIGURE 4



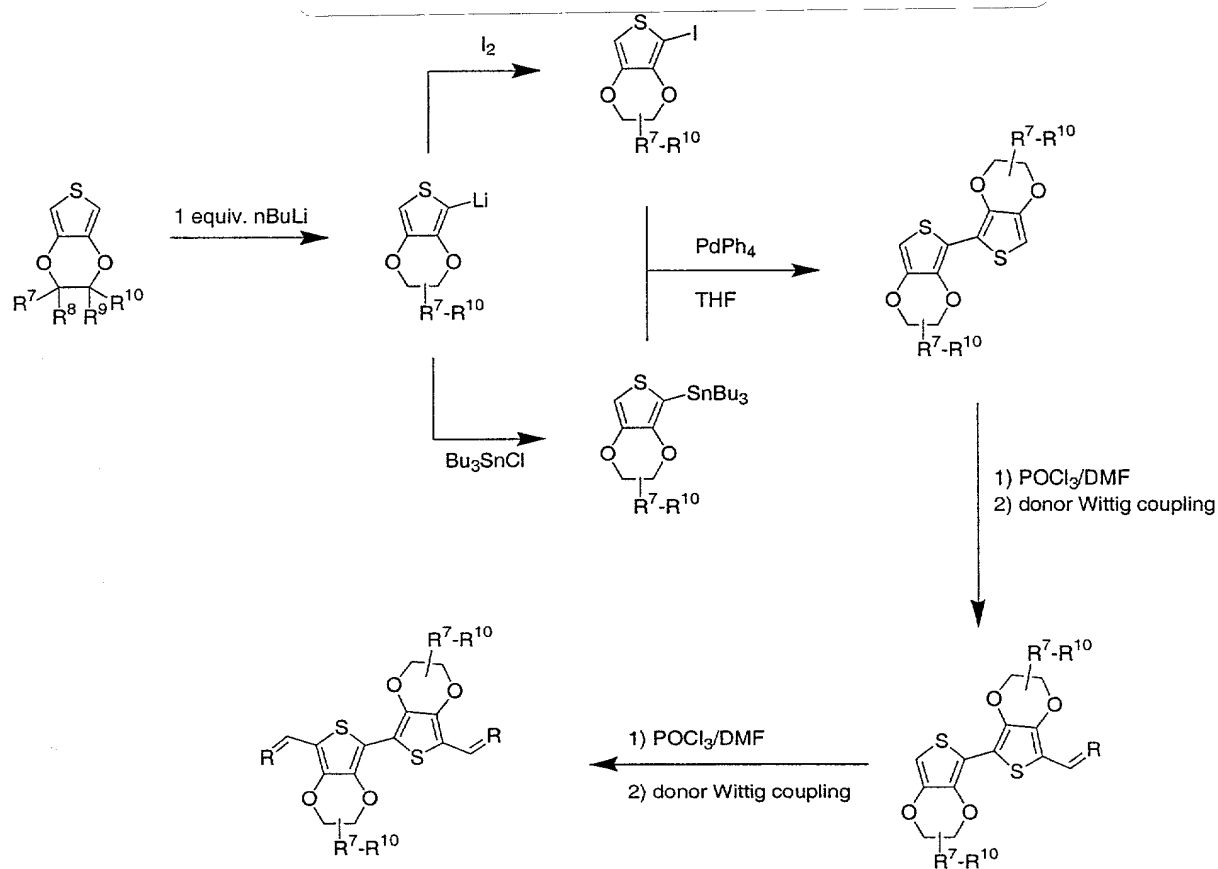
J. Org. Chem. 1971, 36(12), 1645  
 J. Chem. Soc. Perk. Trans. 2 1992, 5, 765  
 J. Mater. Chem. 1999, 9(9), 2227

FIGURE 5



Synth. Comm. 1996, 26(11), 2205  
 Tet. Lett. 2001, 42, 1507.

FIGURE 6



J. Am. Chem. Soc. 2001, 123(19), 4643  
 Chem. Mater. 1996, 8(11), 2659  
 J. Chem. Soc. Perkins Trans. I 1997, 1957

FIGURE 7

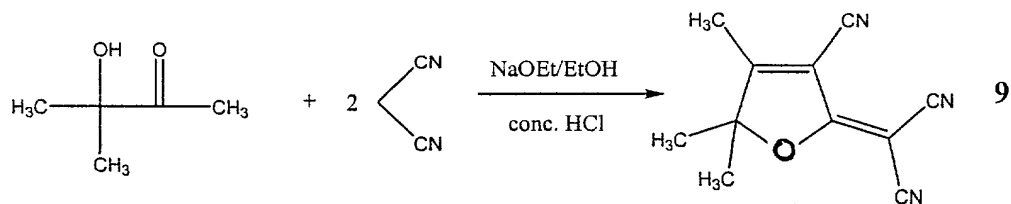


FIGURE 11

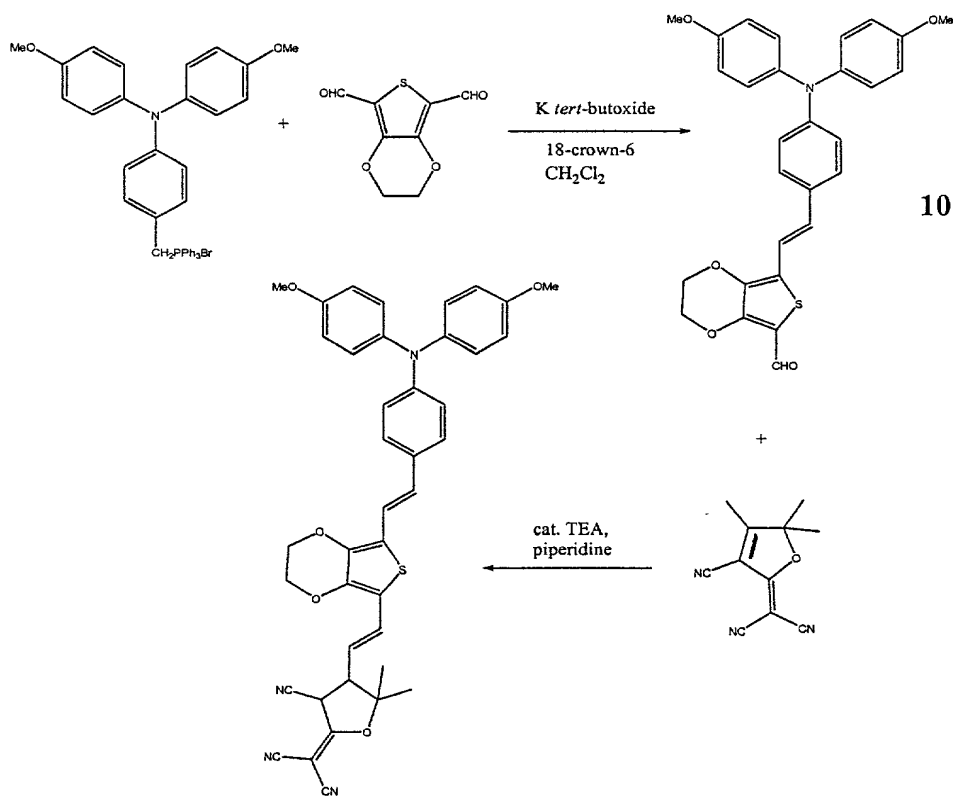


FIGURE 8

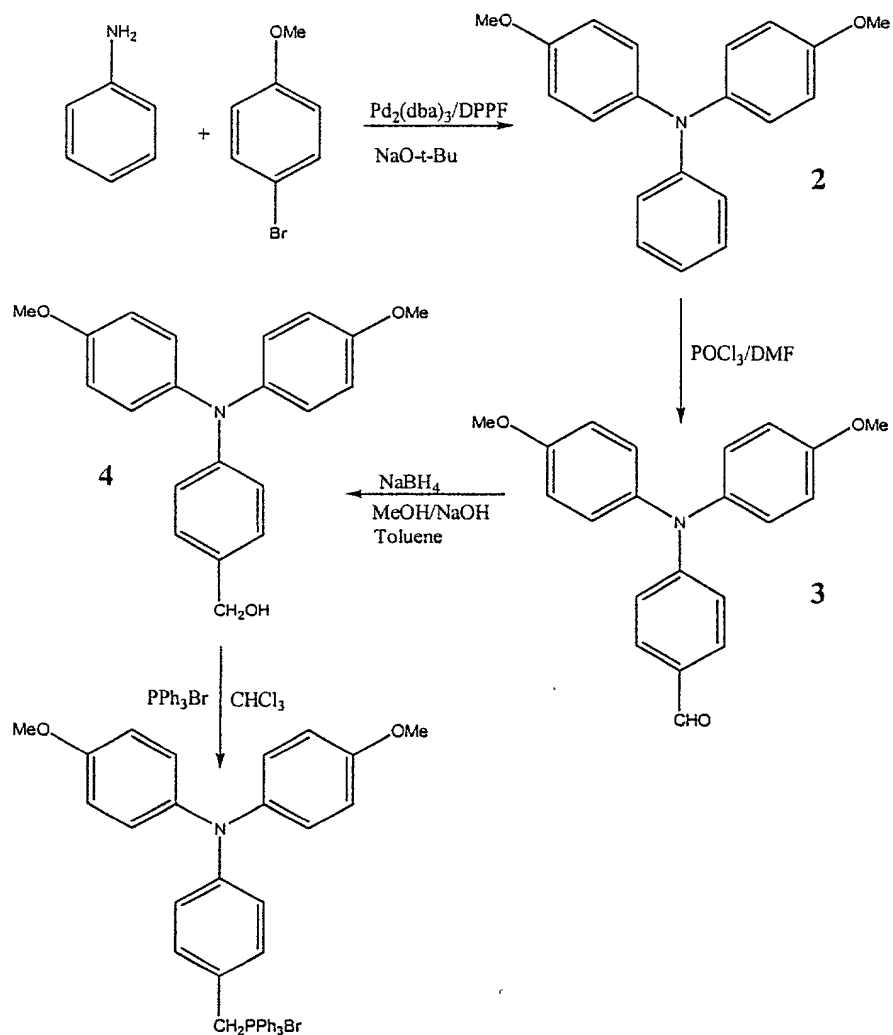


FIGURE 9

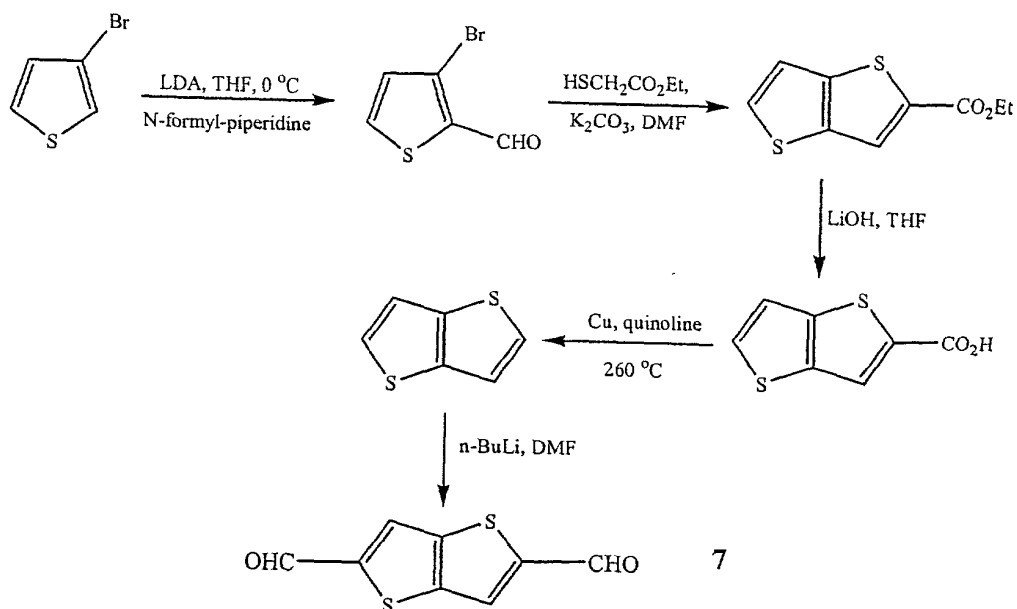


FIGURE 13

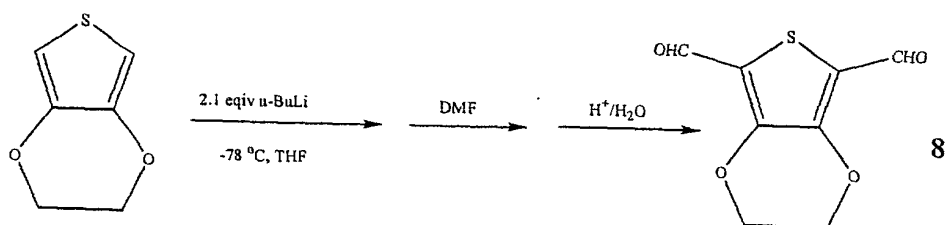


FIGURE 10



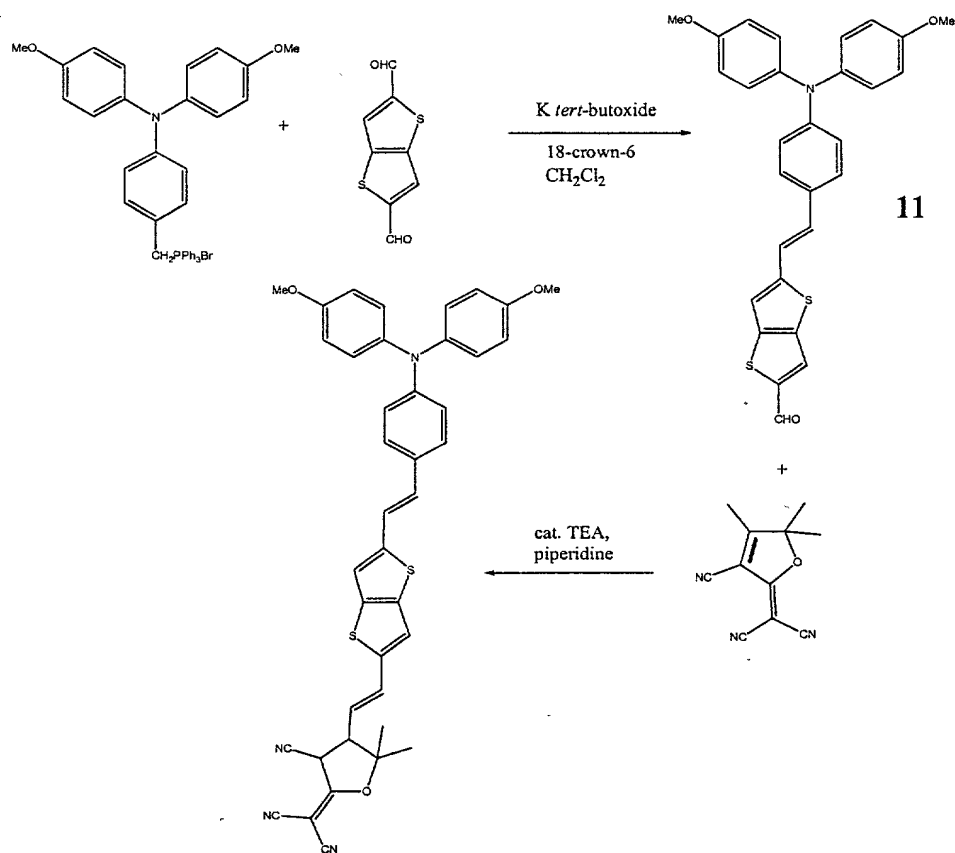


FIGURE 12

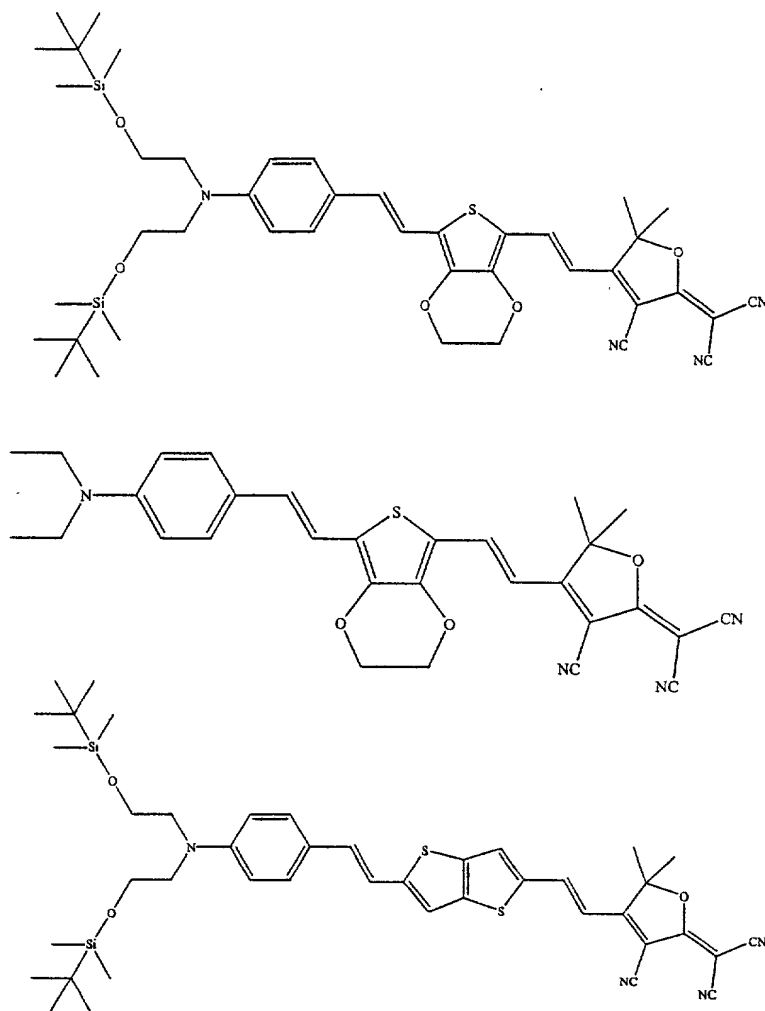


FIGURE 14



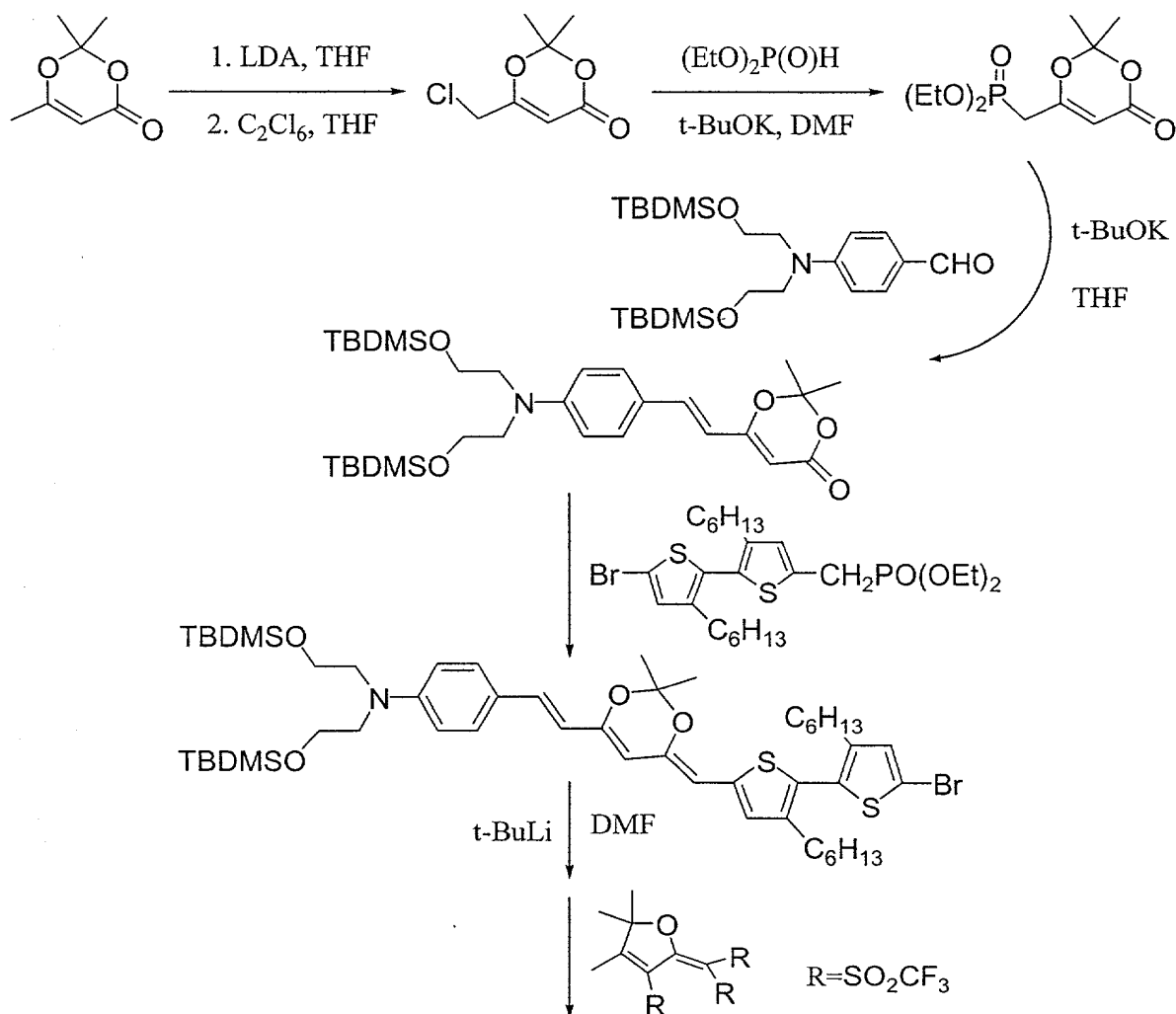


FIGURE 17

# EO coef. vs. chromophore loading

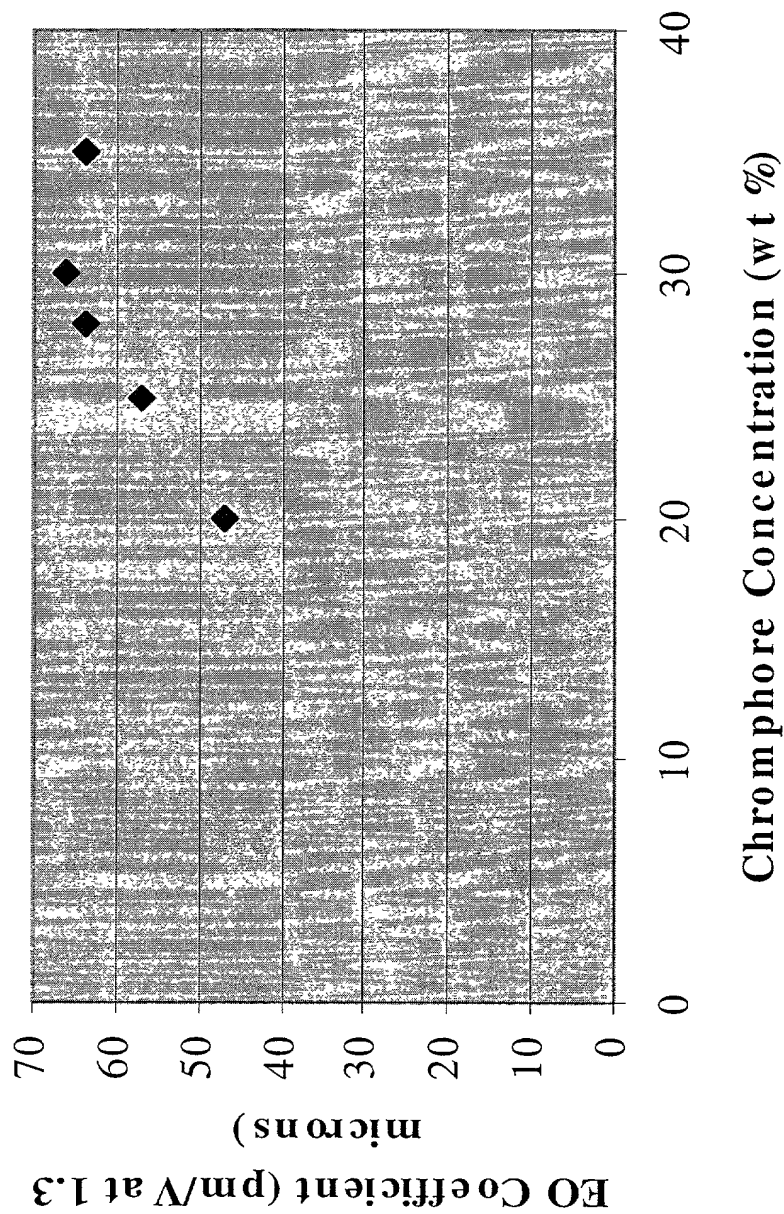


FIGURE 18

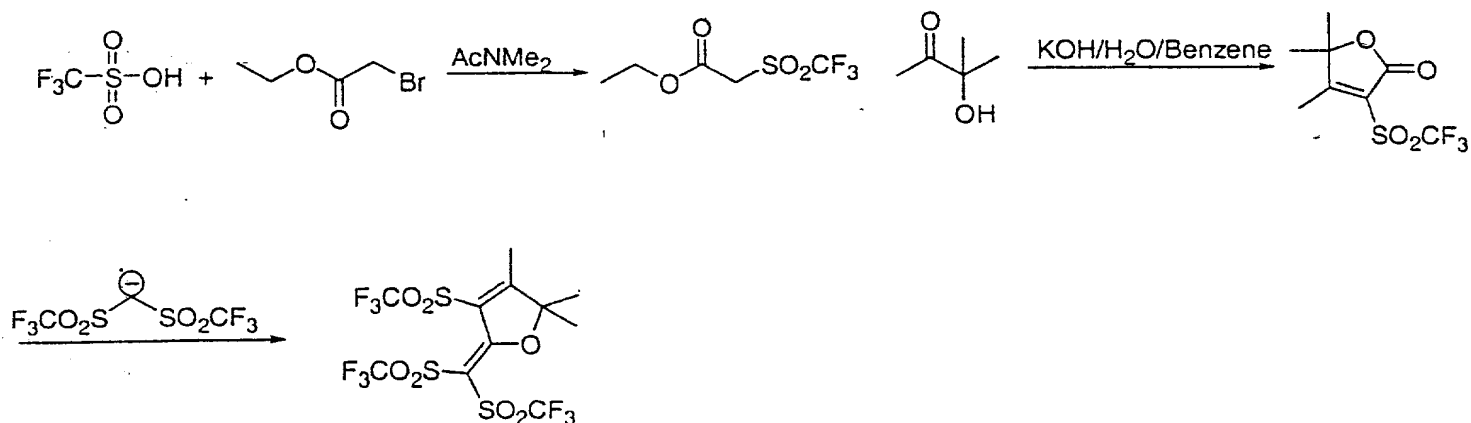


FIGURE 16

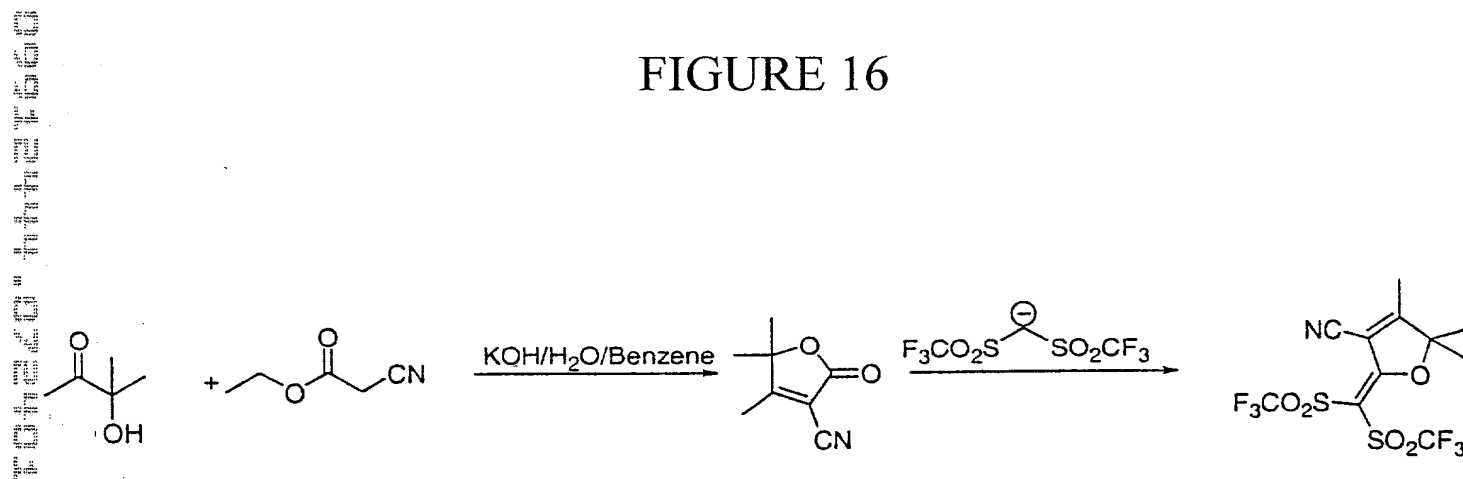


FIGURE 19

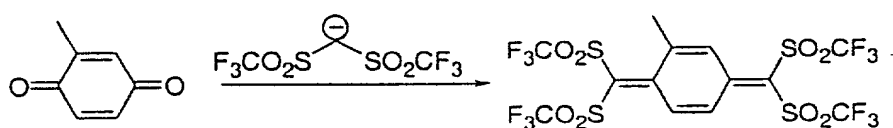


FIGURE 20

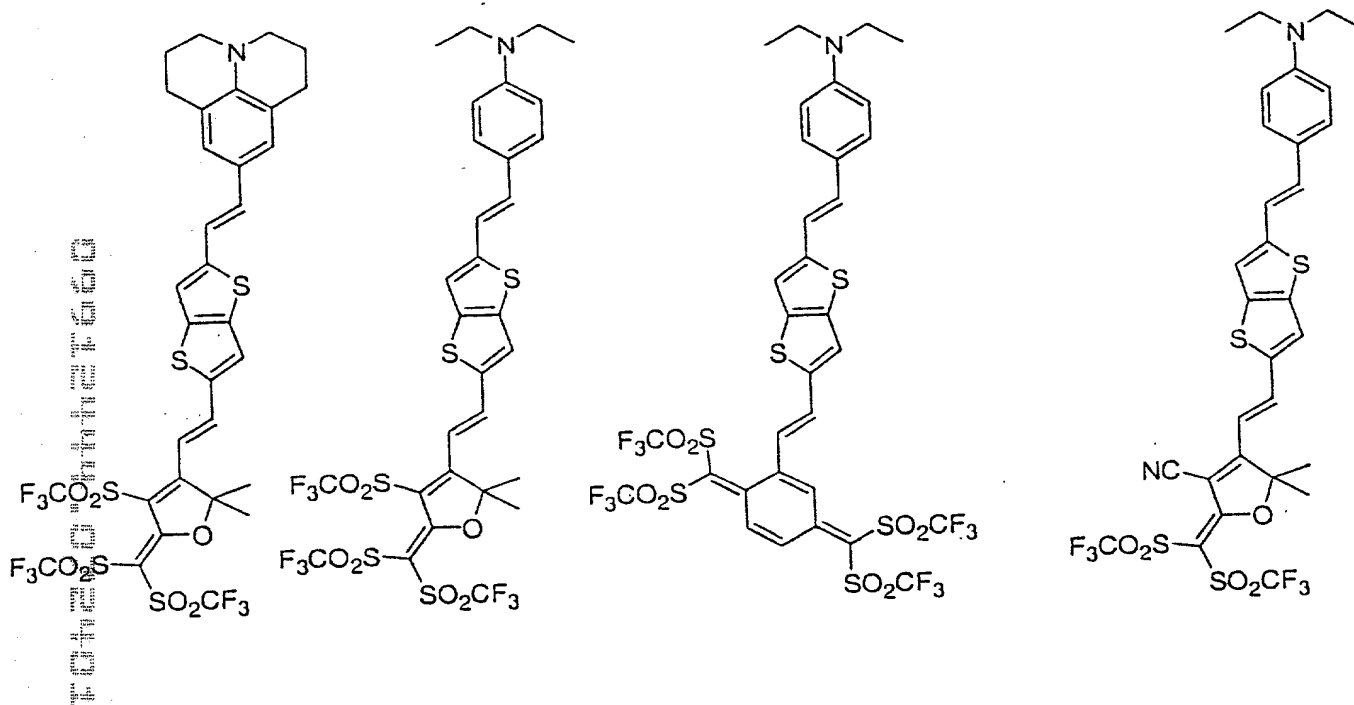


FIGURE 21

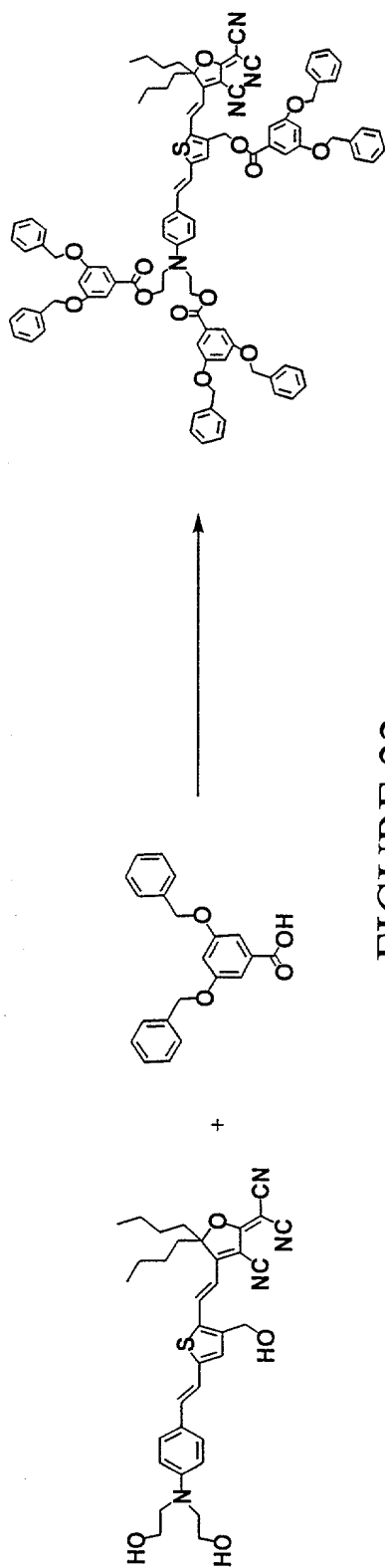


FIGURE 22

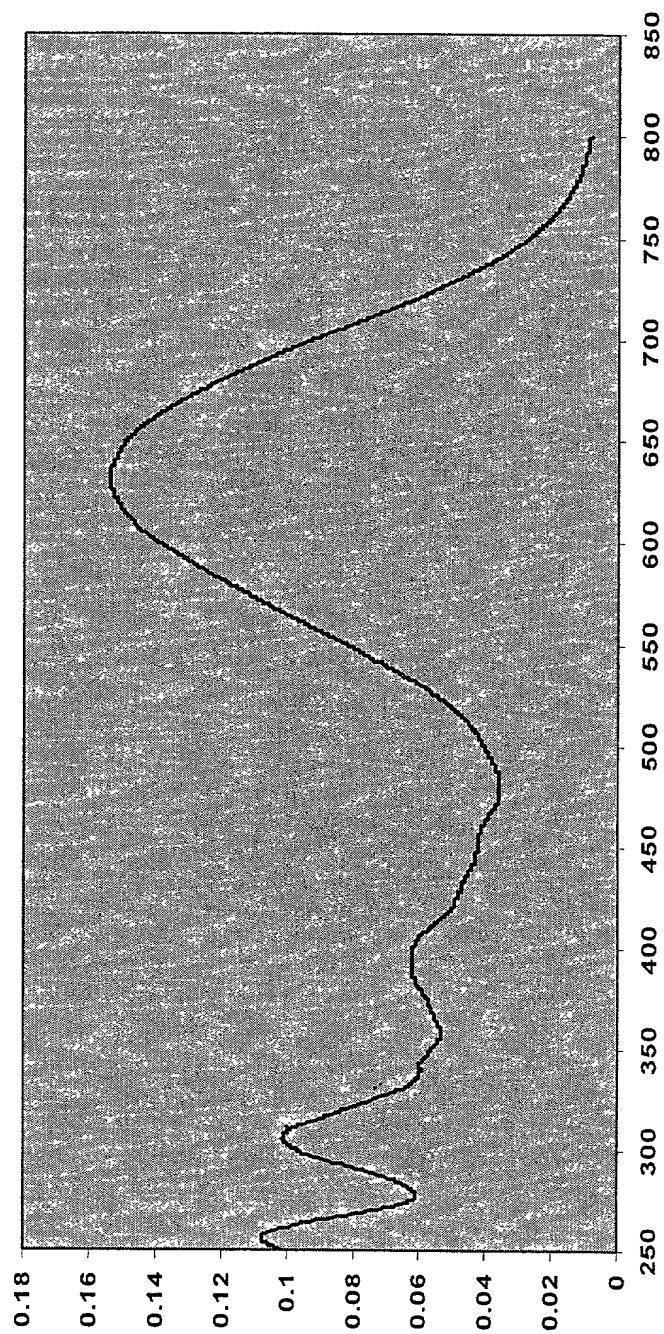


FIGURE 24



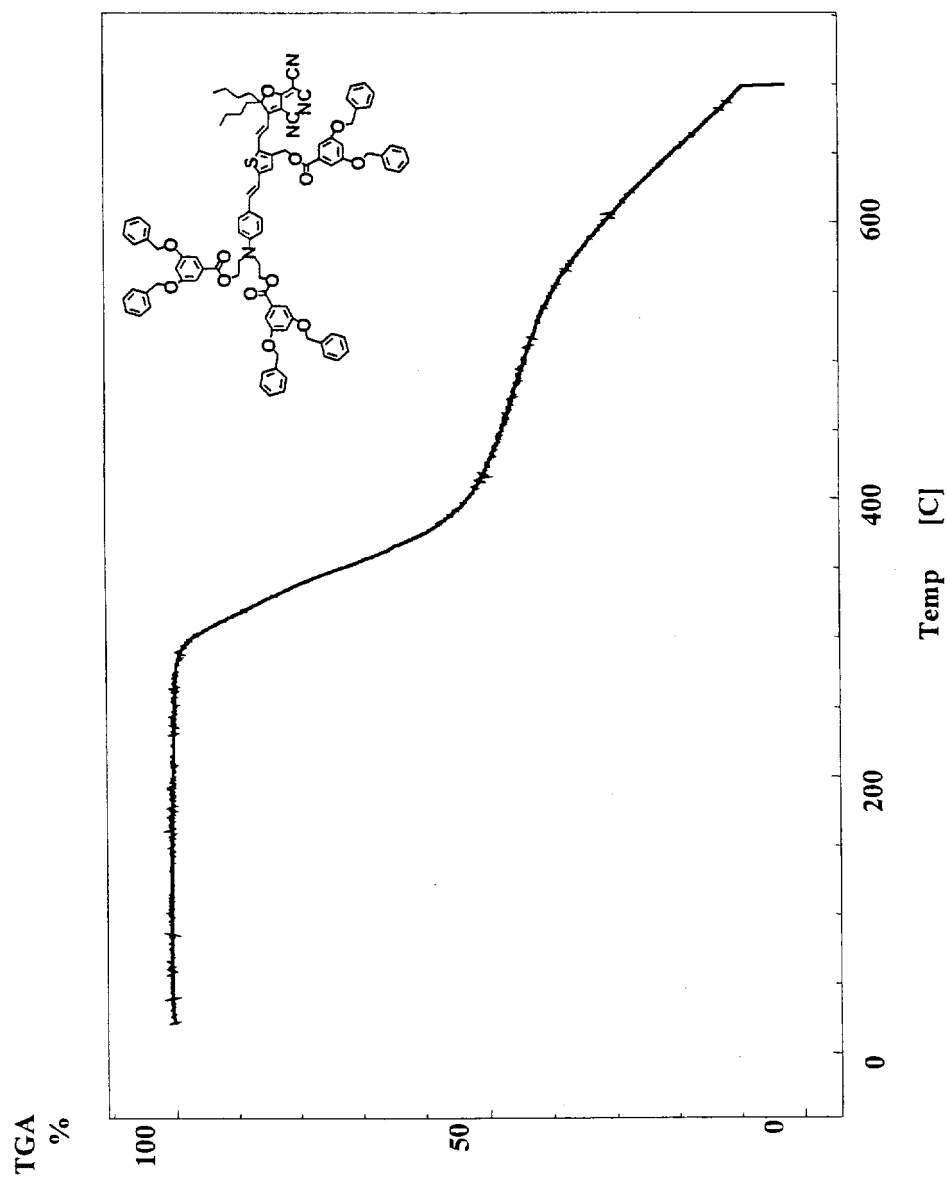


FIGURE 23

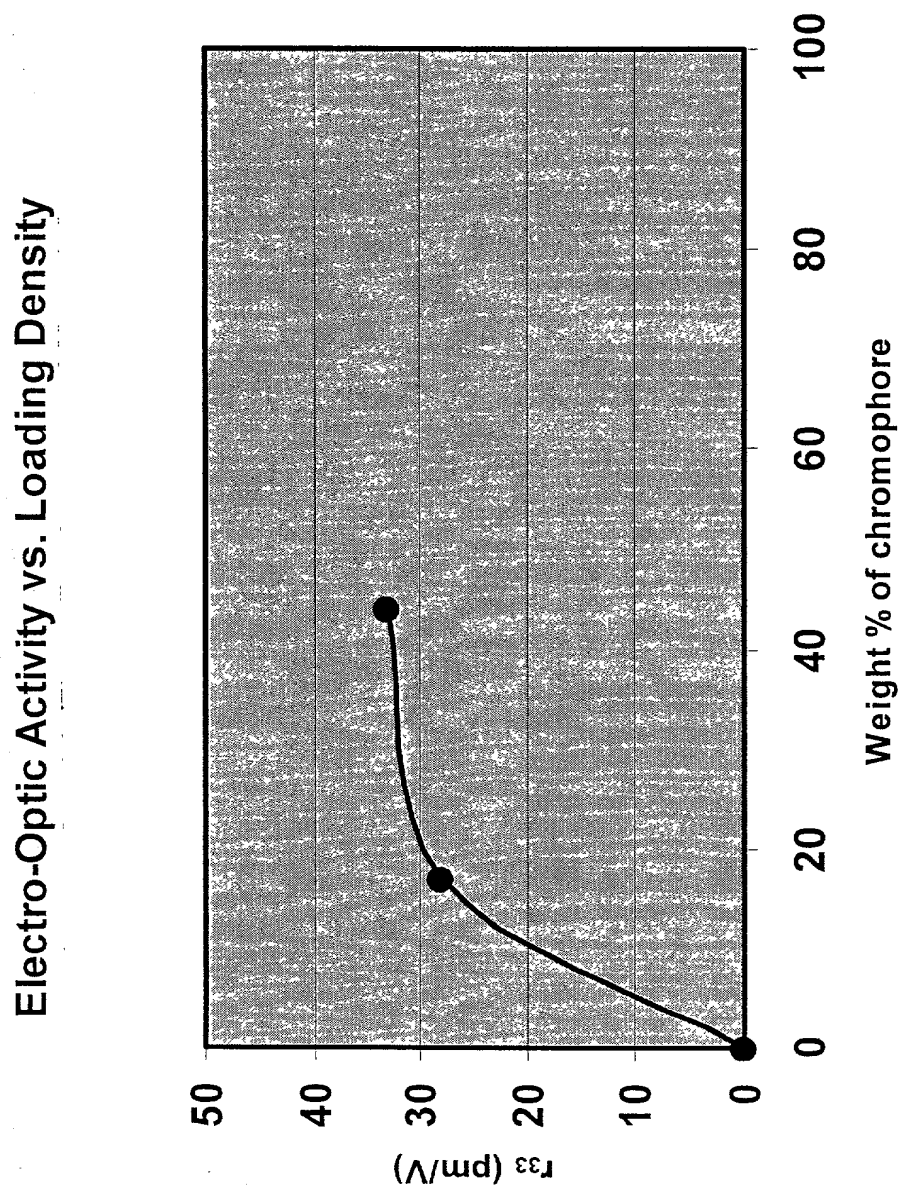


FIGURE 25

COC1=CC=C(N(C1=CC=C2C=C(C=C2)C=C3C(=C(C=C3)C=C4C(=C(C=C4)C=C5C(=C(C=C5)C=C6C(=C(C=C6)C=C7C(=C(C=C7)C=C8C(=C(C=C8)C=C9C(=C(C=C9)C=C10C(=C(C=C10)C=C11C(=C(C=C11)C=C12C(=C(C=C12)C=C13C(=C(C=C13)C=C14C(=C(C=C14)C=C15C(=C(C=C15)C=C16C(=C(C=C16)C=C17C(=C(C=C17)C=C18C(=C(C=C18)C=C19C(=C(C=C19)C=C20C(=C(C=C20)C=C21C(=C(C=C21)C=C22C(=C(C=C22)C=C23C(=C(C=C23)C=C24C(=C(C=C24)C=C25C(=C(C=C25)C=C26C(=C(C=C26)C=C27C(=C(C=C27)C=C28C(=C(C=C28)C=C29C(=C(C=C29)C=C30C(=C(C=C30)C=C31C(=C(C=C31)C=C32C(=C(C=C32)C=C33C(=C(C=C33)C=C34C(=C(C=C34)C=C35C(=C(C=C35)C=C36C(=C(C=C36)C=C37C(=C(C=C37)C=C38C(=C(C=C38)C=C39C(=C(C=C39)C=C40C(=C(C=C40)C=C41C(=C(C=C41)C=C42C(=C(C=C42)C=C43C(=C(C=C43)C=C44C(=C(C=C44)C=C45C(=C(C=C45)C=C46C(=C(C=C46)C=C47C(=C(C=C47)C=C48C(=C(C=C48)C=C49C(=C(C=C49)C=C50C(=C(C=C50)C=C51C(=C(C=C51)C=C52C(=C(C=C52)C=C53C(=C(C=C53)C=C54C(=C(C=C54)C=C55C(=C(C=C55)C=C56C(=C(C=C56)C=C57C(=C(C=C57)C=C58C(=C(C=C58)C=C59C(=C(C=C59)C=C60C(=C(C=C60)C=C61C(=C(C=C61)C=C62C(=C(C=C62)C=C63C(=C(C=C63)C=C64C(=C(C=C64)C=C65C(=C(C=C65)C=C66C(=C(C=C66)C=C67C(=C(C=C67)C=C68C(=C(C=C68)C=C69C(=C(C=C69)C=C70C(=C(C=C70)C=C71C(=C(C=C71)C=C72C(=C(C=C72)C=C73C(=C(C=C73)C=C74C(=C(C=C74)C=C75C(=C(C=C75)C=C76C(=C(C=C76)C=C77C(=C(C=C77)C=C78C(=C(C=C78)C=C79C(=C(C=C79)C=C80C(=C(C=C80)C=C81C(=C(C=C81)C=C82C(=C(C=C82)C=C83C(=C(C=C83)C=C84C(=C(C=C84)C=C85C(=C(C=C85)C=C86C(=C(C=C86)C=C87C(=C(C=C87)C=C88C(=C(C=C88)C=C89C(=C(C=C89)C=C90C(=C(C=C90)C=C91C(=C(C=C91)C=C92C(=C(C=C92)C=C93C(=C(C=C93)C=C94C(=C(C=C94)C=C95C(=C(C=C95)C=C96C(=C(C=C96)C=C97C(=C(C=C97)C=C98C(=C(C=C98)C=C99C(=C(C=C99)C=C100C(=C(C=C100)C=C101C(=C(C=C101)C=C102C(=C(C=C102)C=C103C(=C(C=C103)C=C104C(=C(C=C104)C=C105C(=C(C=C105)C=C106C(=C(C=C106)C=C107C(=C(C=C107)C=C108C(=C(C=C108)C=C109C(=C(C=C109)C=C110C(=C(C=C110)C=C111C(=C(C=C111)C=C112C(=C(C=C112)C=C113C(=C(C=C113)C=C114C(=C(C=C114)C=C115C(=C(C=C115)C=C116C(=C(C=C116)C=C117C(=C(C=C117)C=C118C(=C(C=C118)C=C119C(=C(C=C119)C=C120C(=C(C=C120)C=C121C(=C(C=C121)C=C122C(=C(C=C122)C=C123C(=C(C=C123)C=C124C(=C(C=C124)C=C125C(=C(C=C125)C=C126C(=C(C=C126)C=C127C(=C(C=C127)C=C128C(=C(C=C128)C=C129C(=C(C=C129)C=C130C(=C(C=C130)C=C131C(=C(C=C131)C=C132C(=C(C=C132)C=C133C(=C(C=C133)C=C134C(=C(C=C134)C=C135C(=C(C=C135)C=C136C(=C(C=C136)C=C137C(=C(C=C137)C=C138C(=C(C=C138)C=C139C(=C(C=C139)C=C140C(=C(C=C140)C=C141C(=C(C=C141)C=C142C(=C(C=C142)C=C143C(=C(C=C143)C=C144C(=C(C=C144)C=C145C(=C(C=C145)C=C146C(=C(C=C146)C=C147C(=C(C=C147)C=C148C(=C(C=C148)C=C149C(=C(C=C149)C=C150C(=C(C=C150)C=C151C(=C(C=C151)C=C152C(=C(C=C152)C=C153C(=C(C=C153)C=C154C(=C(C=C154)C=C155C(=C(C=C155)C=C156C(=C(C=C156)C=C157C(=C(C=C157)C=C158C(=C(C=C158)C=C159C(=C(C=C159)C=C160C(=C(C=C160)C=C161C(=C(C=C161)C=C162C(=C(C=C162)C=C163C(=C(C=C163)C=C164C(=C(C=C164)C=C165C(=C(C=C165)C=C166C(=C(C=C166)C=C167C(=C(C=C167)C=C168C(=C(C=C168)C=C169C(=C(C=C169)C=C170C(=C(C=C170)C=C171C(=C(C=C171)C=C172C(=C(C=C172)C=C173C(=C(C=C173)C=C174C(=C(C=C174)C=C175C(=C(C=C175)C=C176C(=C(C=C176)C=C177C(=C(C=C177)C=C178C(=C(C=C178)C=C179C(=C(C=C179)C=C180C(=C(C=C180)C=C181C(=C(C=C181)C=C182C(=C(C=C182)C=C183C(=C(C=C183)C=C184C(=C(C=C184)C=C185C(=C(C=C185)C=C186C(=C(C=C186)C=C187C(=C(C=C187)C=C188C(=C(C=C188)C=C189C(=C(C=C189)C=C190C(=C(C=C190)C=C191C(=C(C=C191)C=C192C(=C(C=C192)C=C193C(=C(C=C193)C=C194C(=C(C=C194)C=C195C(=C(C=C195)C=C196C(=C(C=C196)C=C197C(=C(C=C197)C=C198C(=C(C=C198)C=C199C(=C(C=C199)C=C200C(=C(C=C200)C=C201C(=C(C=C201)C=C202C(=C(C=C202)C=C203C(=C(C=C203)C=C204C(=C(C=C204)C=C205C(=C(C=C205)C=C206C(=C(C=C206)C=C207C(=C(C=C207)C=C208C(=C(C=C208)C=C209C(=C(C=C209)C=C210C(=C(C=C210)C=C211C(=C(C=C211)C=C212C(=C(C=C212)C=C213C(=C(C=C213)C=C214C(=C(C=C214)C=C215C(=C(C=C215)C=C216C(=C(C=C216)C=C217C(=C(C=C217)C=C218C(=C(C=C218)C=C219C(=C(C=C219)C=C220C(=C(C=C220)C=C221C(=C(C=C221)C=C222C(=C(C=C222)C=C223C(=C(C=C223)C=C224C(=C(C=C224)C=C225C(=C(C=C225)C=C226C(=C(C=C226)C=C227C(=C(C=C227)C=C228C(=C(C=C228)C=C229C(=C(C=C229)C=C230C(=C(C=C230)C=C231C(=C(C=C231)C=C232C(=C(C=C232)C=C233C(=C(C=C233)C=C234C(=C(C=C234)C=C235C(=C(C=C235)C=C236C(=C(C=C236)C=C237C(=C(C=C237)C=C238C(=C(C=C238)C=C239C(=C(C=C239)C=C240C(=C(C=C240)C=C241C(=C(C=C241)C=C242C(=C(C=C242)C=C243C(=C(C=C243)C=C244C(=C(C=C244)C=C245C(=C(C=C245)C=C246C(=C(C=C246)C=C247C(=C(C=C247)C=C248C(=C(C=C248)C=C249C(=C(C=C249)C=C250C(=C(C=C250)C=C251C(=C(C=C251)C=C252C(=C(C=C252)C=C253C(=C(C=C253)C=C254C(=C(C=C254)C=C255C(=C(C=C255)C=C256C(=C(C=C256)C=C257C(=C(C=C257)C=C258C(=C(C=C258)C=C259C(=C(C=C259)C=C260C(=C(C=C260)C=C261C(=C(C=C261)C=C262C(=C(C=C262)C=C263C(=C(C=C263)C=C264C(=C(C=C264)C=C265C(=C(C=C265)C=C266C(=C(C=C266)C=C267C(=C(C=C267)C=C268C(=C(C=C268)C=C269C(=C(C=C269)C=C270C(=C(C=C270)C=C271C(=C(C=C271)C=C272C(=C(C=C272)C=C273C(=C(C=C273)C=C274C(=C(C=C274)C=C275C(=C(C=C275)C=C276C(=C(C=C276)C=C277C(=C(C=C277)C=C278C(=C(C=C278)C=C279C(=C(C=C279)C=C280C(=C(C=C280)C=C281C(=C(C=C281)C=C282C(=C(C=C282)C=C283C(=C(C=C283)C=C284C(=C(C=C284)C=C285C(=C(C=C285)C=C286C(=C(C=C286)C=C287C(=C(C=C287)C=C288C(=

Author	Year	Country	Sample Size	Study Design	Findings
Wang et al.	2000	China	1000	Case-control	Increased risk of lung cancer with smoking and drinking.
Li et al.	2001	China	1500	Case-control	Increased risk of lung cancer with smoking and drinking.
Wang et al.	2002	China	2000	Case-control	Increased risk of lung cancer with smoking and drinking.
Li et al.	2003	China	2500	Case-control	Increased risk of lung cancer with smoking and drinking.
Wang et al.	2004	China	3000	Case-control	Increased risk of lung cancer with smoking and drinking.
Li et al.	2005	China	3500	Case-control	Increased risk of lung cancer with smoking and drinking.
Wang et al.	2006	China	4000	Case-control	Increased risk of lung cancer with smoking and drinking.
Li et al.	2007	China	4500	Case-control	Increased risk of lung cancer with smoking and drinking.
Wang et al.	2008	China	5000	Case-control	Increased risk of lung cancer with smoking and drinking.
Li et al.	2009	China	5500	Case-control	Increased risk of lung cancer with smoking and drinking.
Wang et al.	2010	China	6000	Case-control	Increased risk of lung cancer with smoking and drinking.
Li et al.	2011	China	6500	Case-control	Increased risk of lung cancer with smoking and drinking.
Wang et al.	2012	China	7000	Case-control	Increased risk of lung cancer with smoking and drinking.
Li et al.	2013	China	7500	Case-control	Increased risk of lung cancer with smoking and drinking.
Wang et al.	2014	China	8000	Case-control	Increased risk of lung cancer with smoking and drinking.
Li et al.	2015	China	8500	Case-control	Increased risk of lung cancer with smoking and drinking.
Wang et al.	2016	China	9000	Case-control	Increased risk of lung cancer with smoking and drinking.
Li et al.	2017	China	9500	Case-control	Increased risk of lung cancer with smoking and drinking.
Wang et al.	2018	China	10000	Case-control	Increased risk of lung cancer with smoking and drinking.
Li et al.	2019	China	10500	Case-control	Increased risk of lung cancer with smoking and drinking.
Wang et al.	2020	China	11000	Case-control	Increased risk of lung cancer with smoking and drinking.
Li et al.	2021	China	11500	Case-control	Increased risk of lung cancer with smoking and drinking.
Wang et al.	2022	China	12000	Case-control	Increased risk of lung cancer with smoking and drinking.
Li et al.	2023	China	12500	Case-control	Increased risk of lung cancer with smoking and drinking.
Wang et al.	2024	China	13000	Case-control	Increased risk of lung cancer with smoking and drinking.
Li et al.	2025	China	13500	Case-control	Increased risk of lung cancer with smoking and drinking.

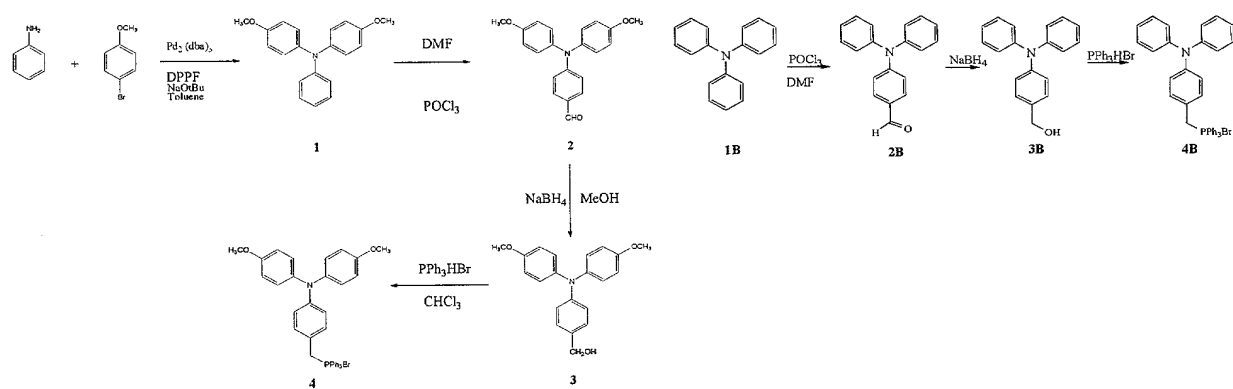


FIGURE 27

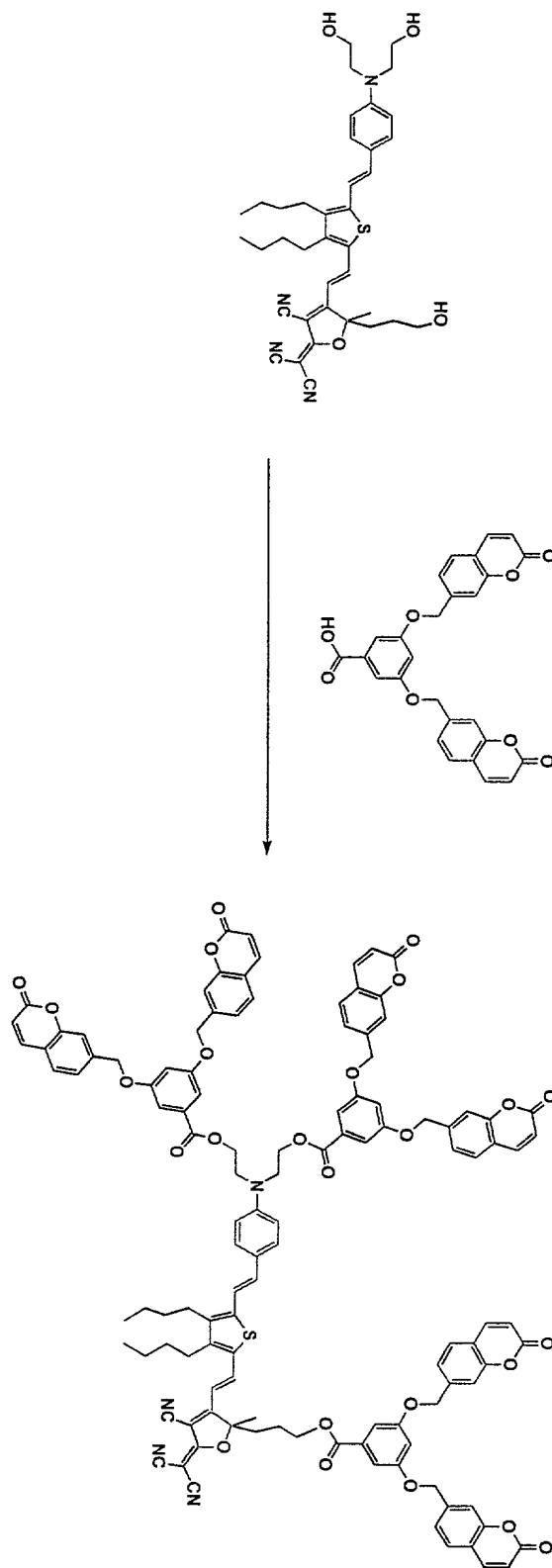
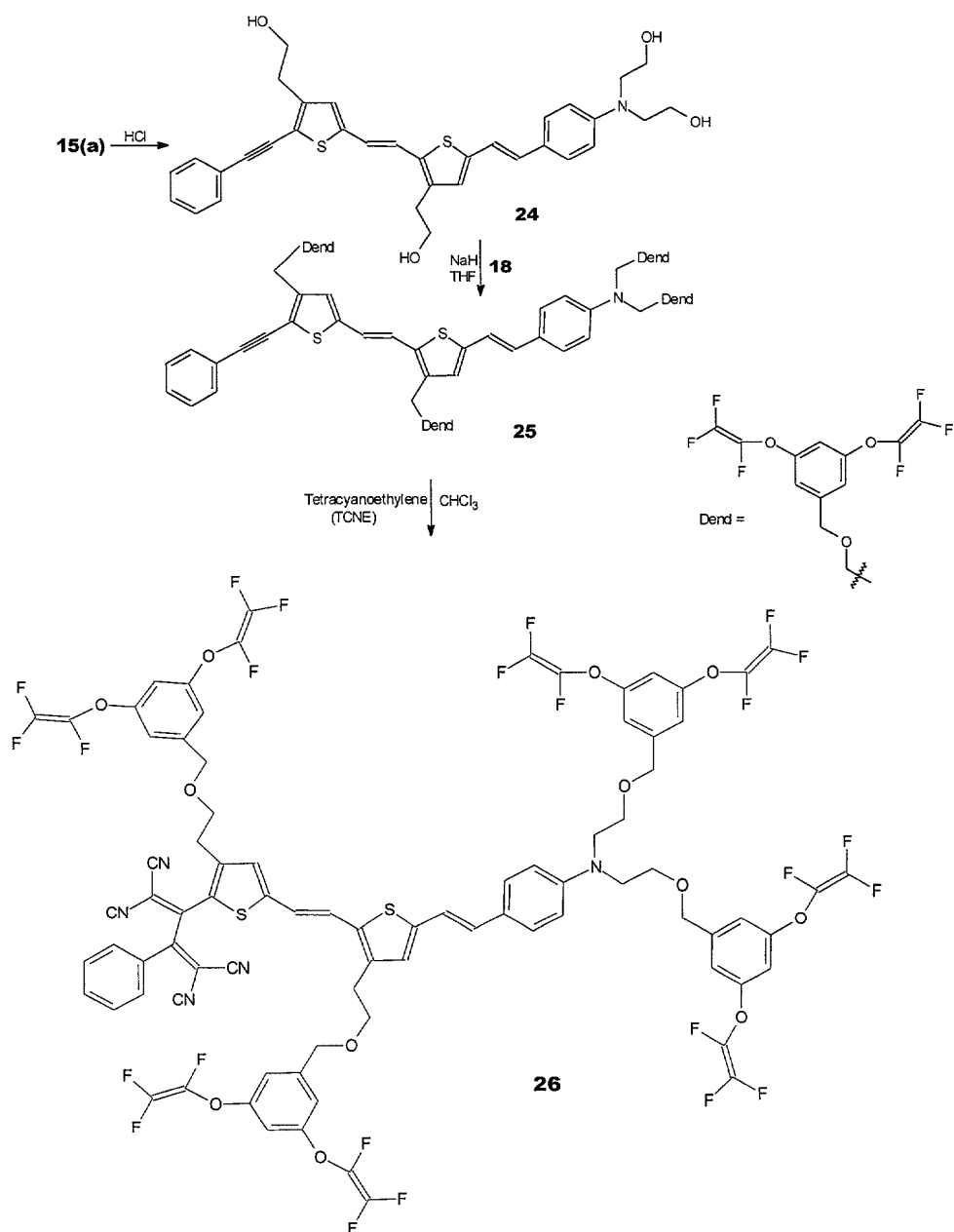
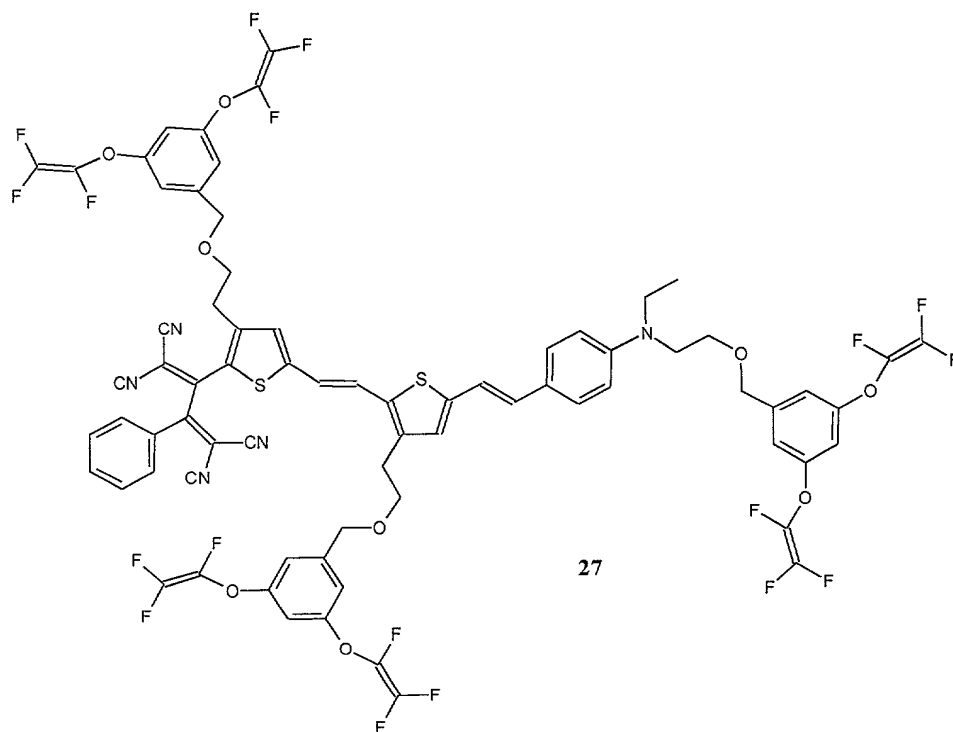
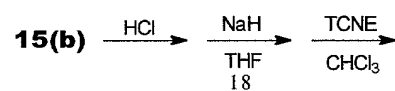
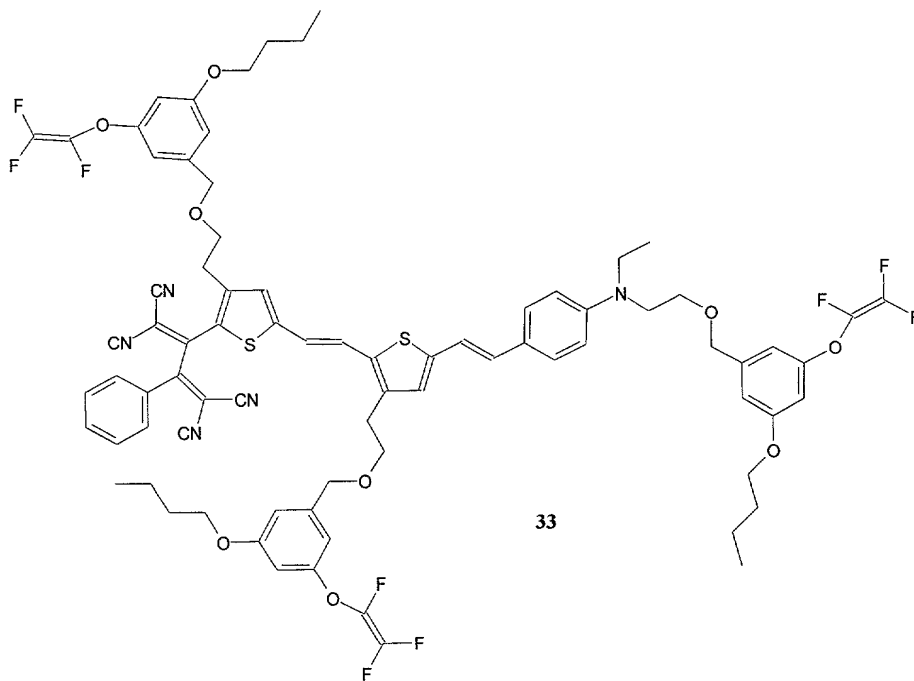
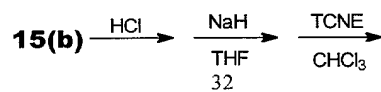


FIGURE 28

**FIGURE 29**

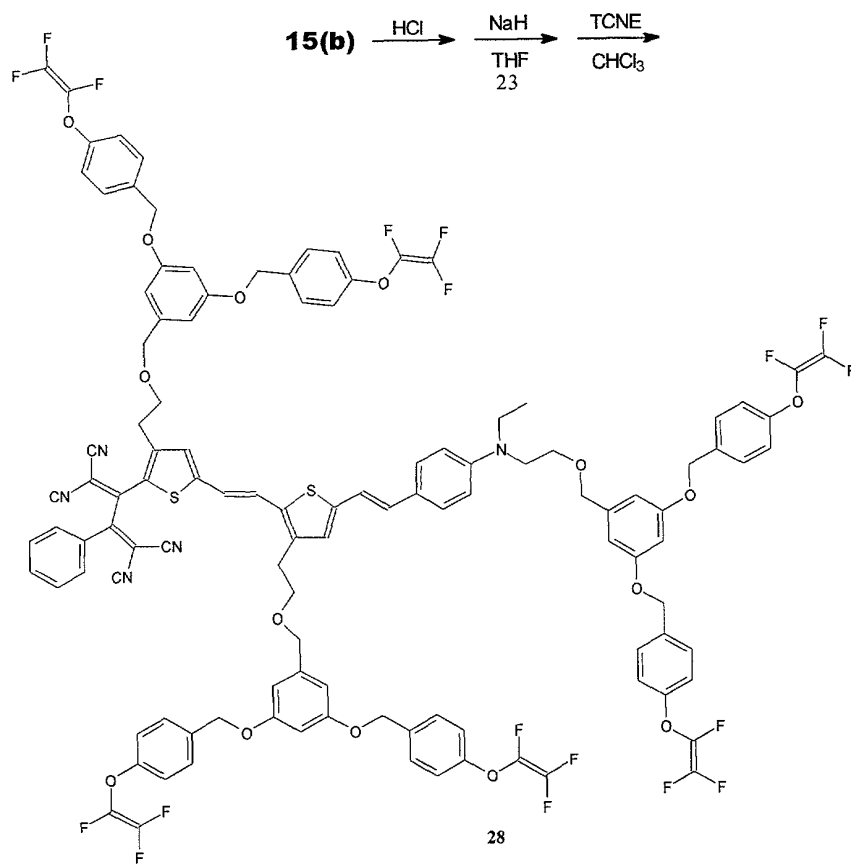


**FIGURE 30**

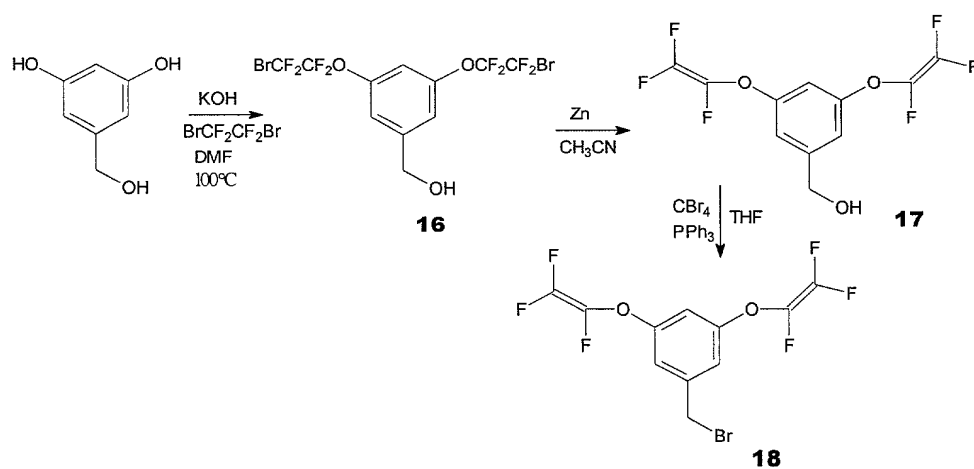


**FIGURE 31**

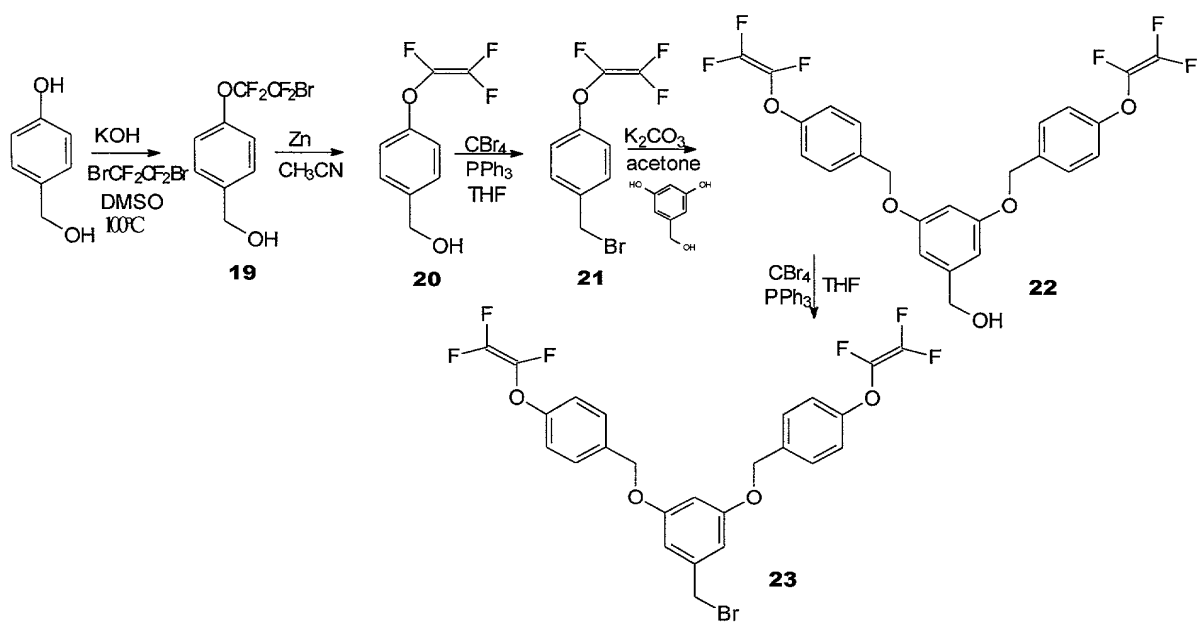


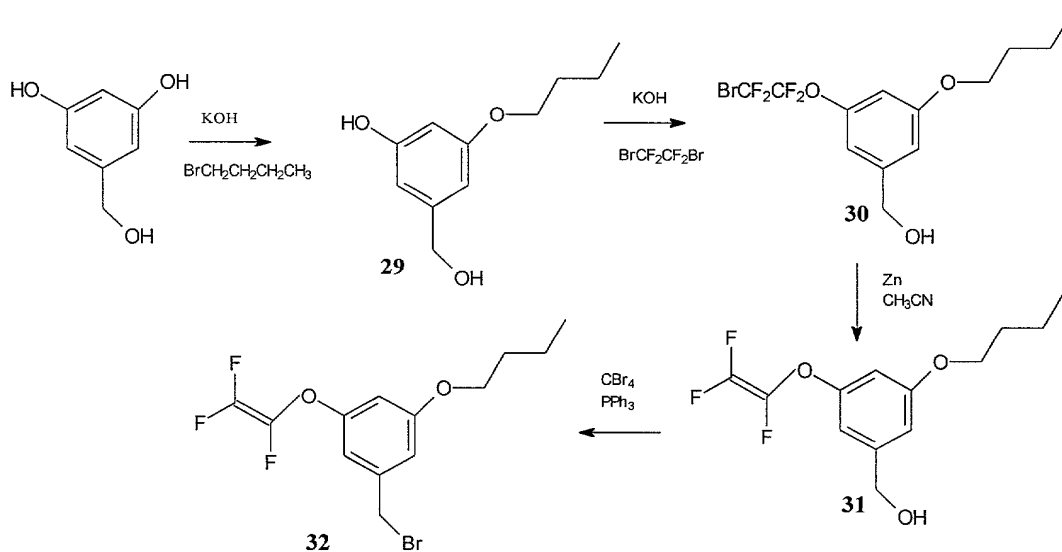


**FIGURE 32**

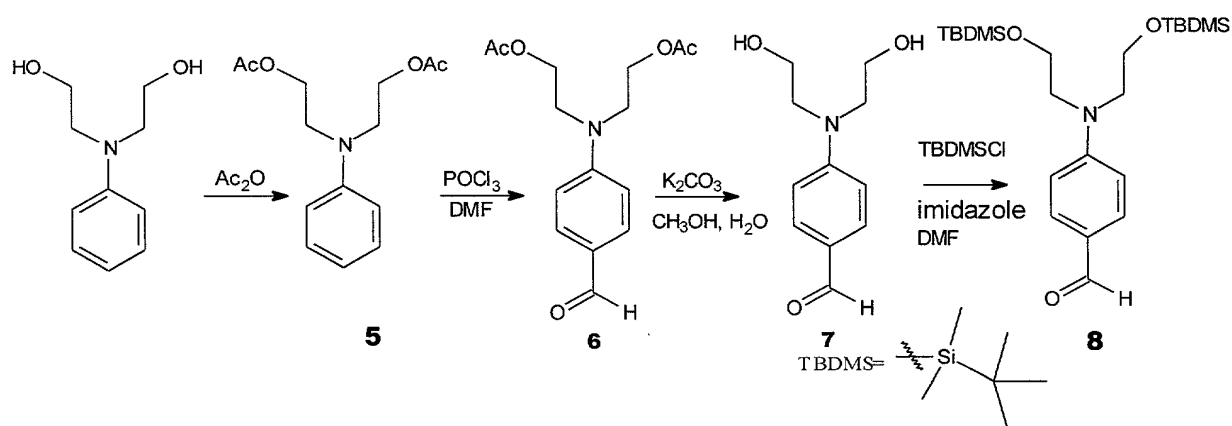


**FIGURE 33**

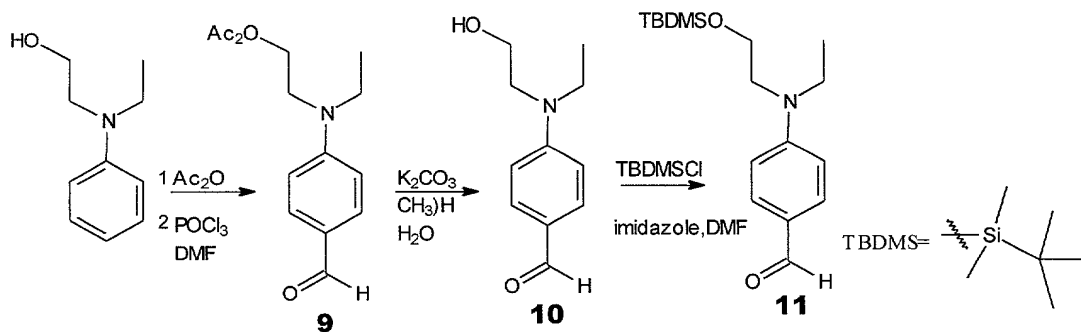
**FIGURE 34**



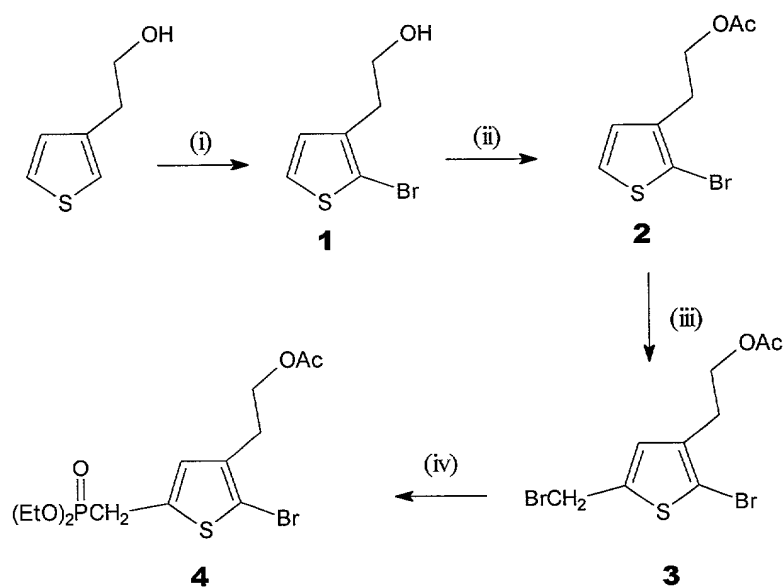
**FIGURE 35**



**FIGURE 36**

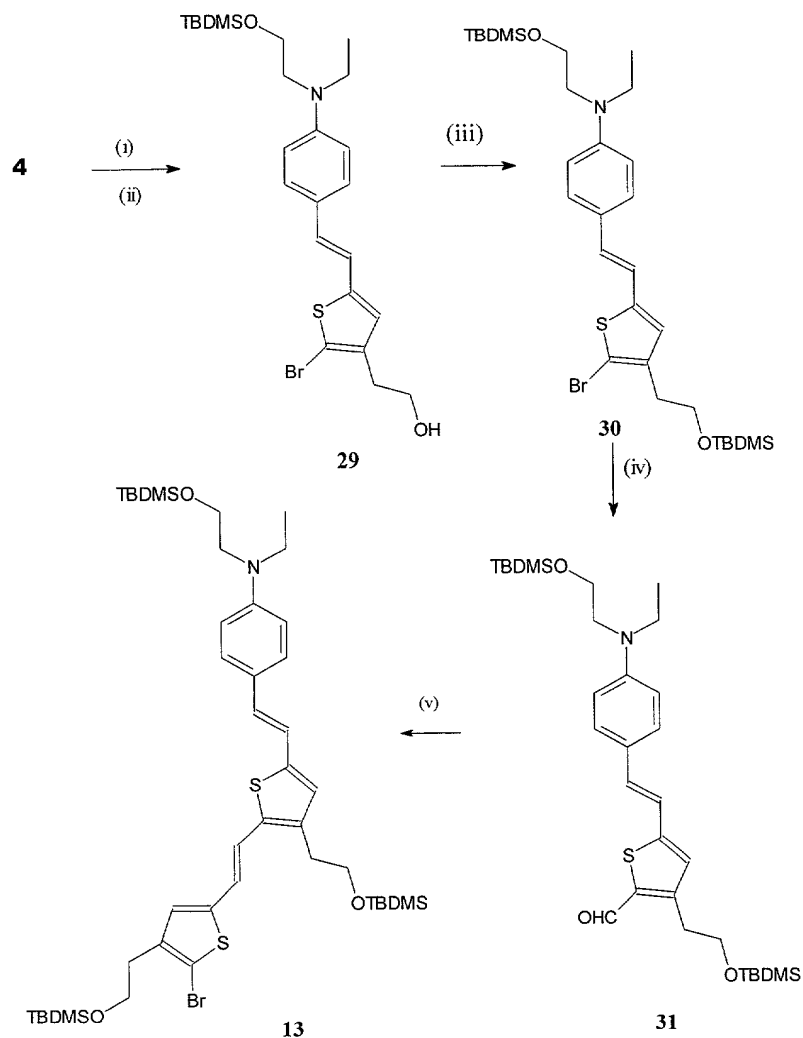


**FIGURE 37**



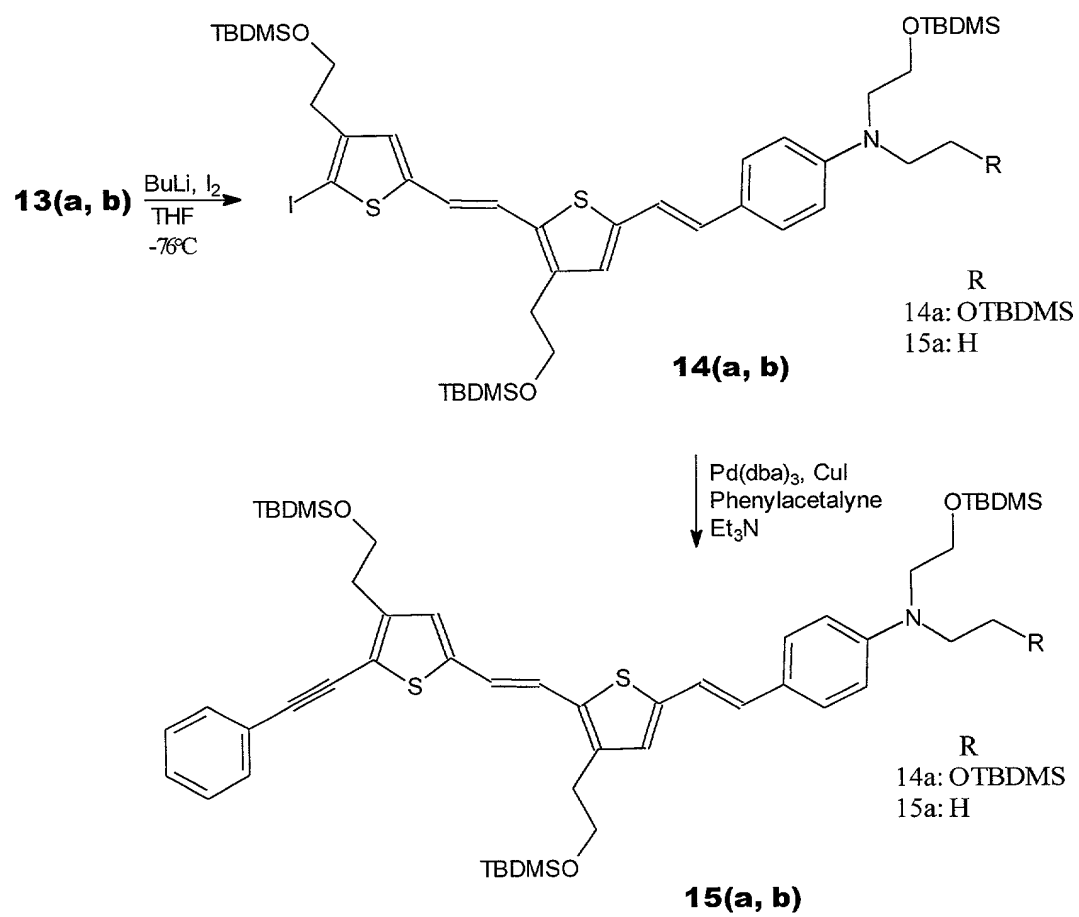
(i) NBS, DMF, RT; (ii) acetic anhydride, 60°C; (iii) (CH<sub>2</sub>O)<sub>n</sub>, 45% HBr/HOAc, HOAc, 50°C;  
(iv) P(OEt)<sub>3</sub>, DMF, 120°C.

**FIGURE 38**



(i) 11, KOtBu, THF, 0°C; (ii) K<sub>2</sub>CO<sub>3</sub>, CH<sub>3</sub>OH, H<sub>2</sub>O, RT; (iii) (CH<sub>3</sub>)<sub>3</sub>CSi(CH<sub>3</sub>)<sub>2</sub>Cl, imidazole, DMF, 50°C; (iv) a. nBu-Li, THF, -78°C; b. DMF, RT; (v) a. 4, KOtBu, THF, 0°C; b. K<sub>2</sub>CO<sub>3</sub>, CH<sub>3</sub>OH, H<sub>2</sub>O, RT; c. (CH<sub>3</sub>)<sub>3</sub>CSi(CH<sub>3</sub>)<sub>2</sub>Cl, imidazole, DMF, 50°C.

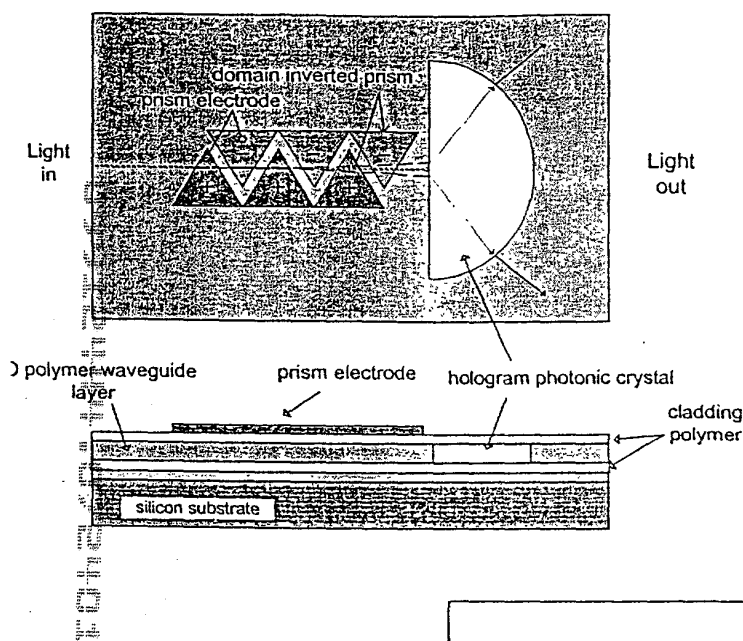
**FIGURE 39**



**FIGURE 40**



# Large Angle Laser Beam Scanner



EO waveguide prism introduces a small deflection angle to initialize the beam scanning. The half-circle 2-D photonic crystal region is imbedded into the waveguide, so that the deflection angle is "amplified" as the light pass through the crystal region. 3D scanning can also be provided if a 3-D structure is built

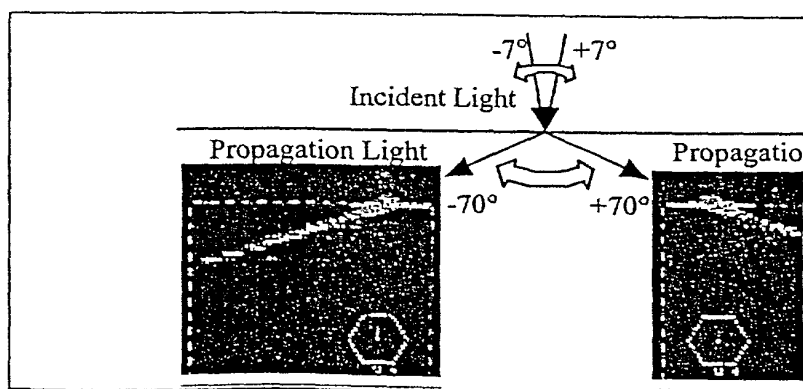
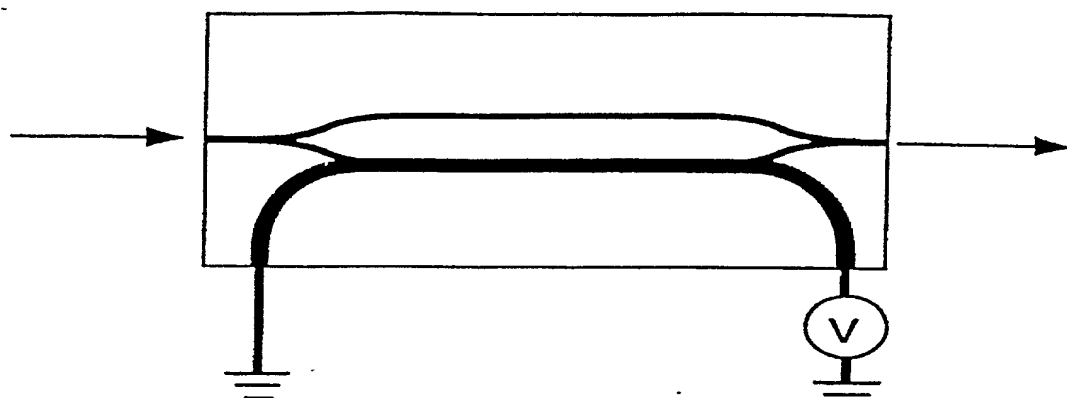
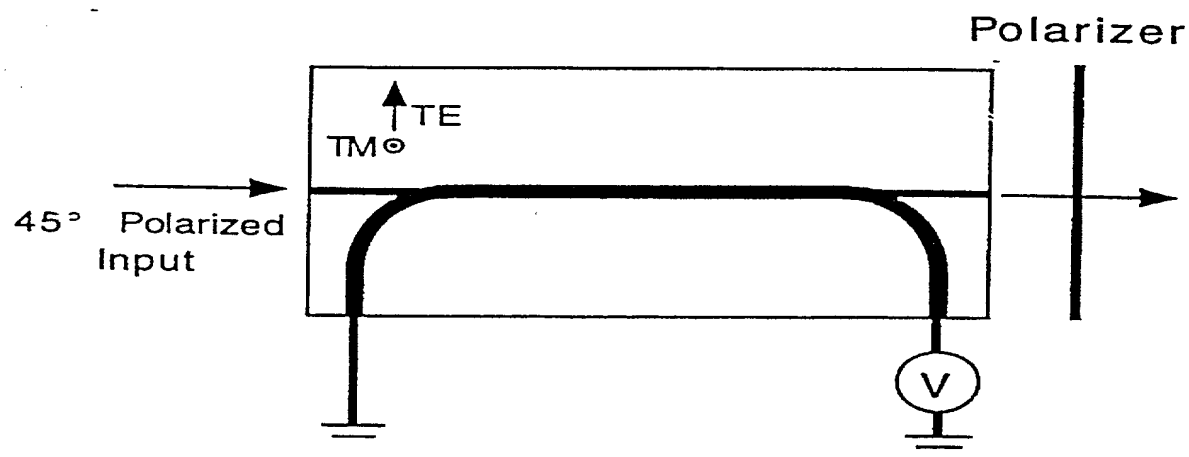


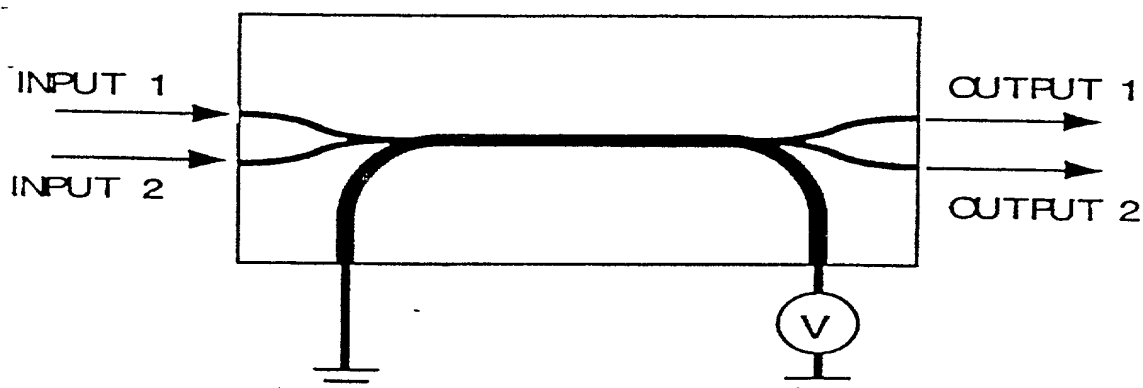
FIGURE 41



Mach Zehnder Modulator

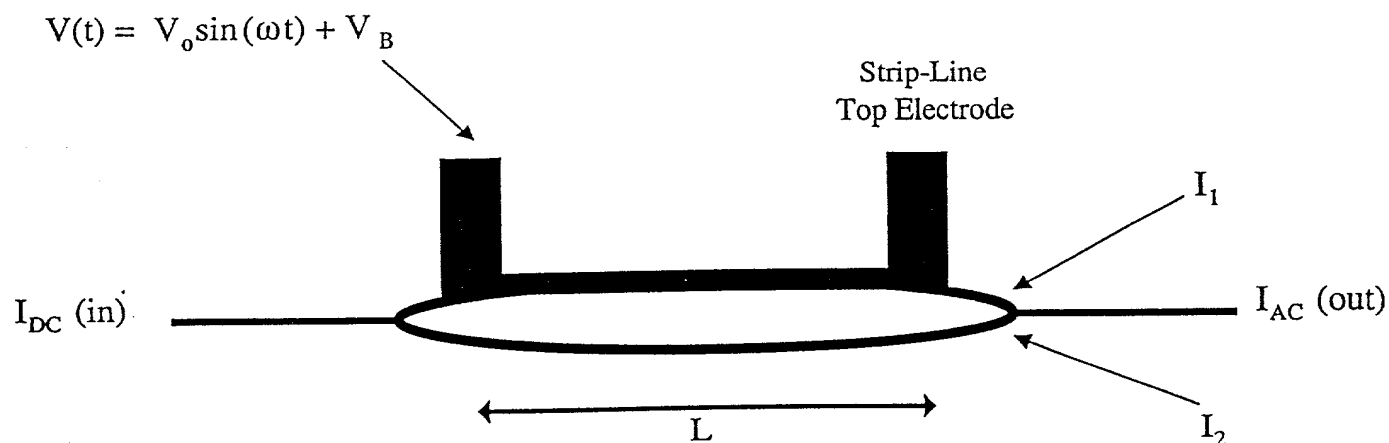


Birefringent Modulator



Directional Coupler

FIGURE 42



$$I_{AC} \text{ (out)} = I_1 + I_2 + 2(I_1 I_2)^{1/2} \sin(\rho V_o \sin(\omega t))$$

$$\rho = 2\pi r_{33} n^3 L V_o / T \lambda$$

### Comparison of key features of simple devices

	<u>Mach Zehnder Interferometer</u>	<u>Birefringent Modulator</u>	<u>Directional Coupler</u>
$r_{\text{eff}}$	$r_{33}$	$r_{33} - r_{13}$	$r_{33}$
$V_{\pi}$	$V_{\pi \text{MZ}}$	$1.5 V_{\pi \text{MZ}}$	$1.73 V_{\pi \text{MZ}}$
Mod. Power	$P_{\text{MZ}}$	$2.75 P_{\text{MZ}}$	$3 P_{\text{MZ}}$

FIGURE 43

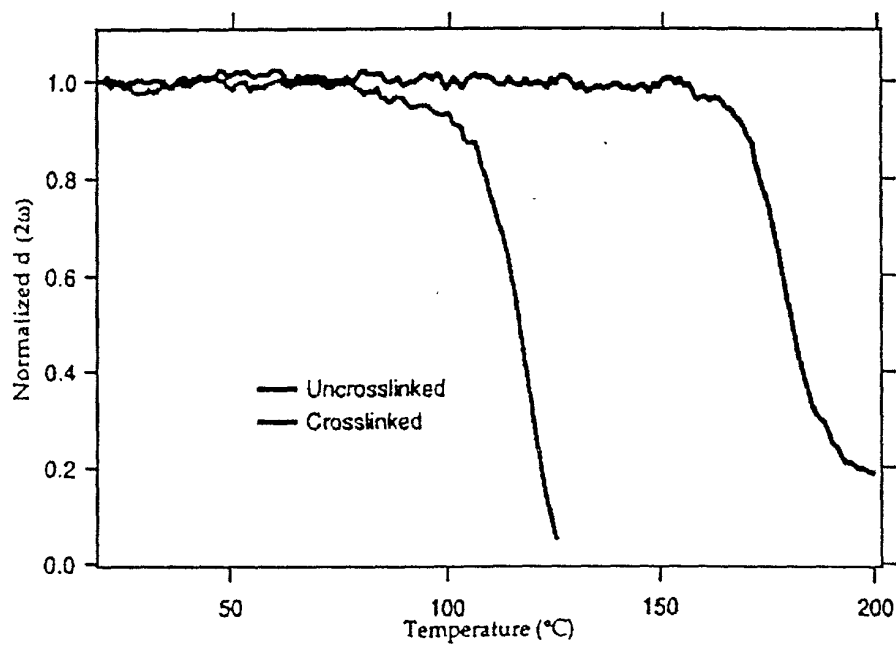
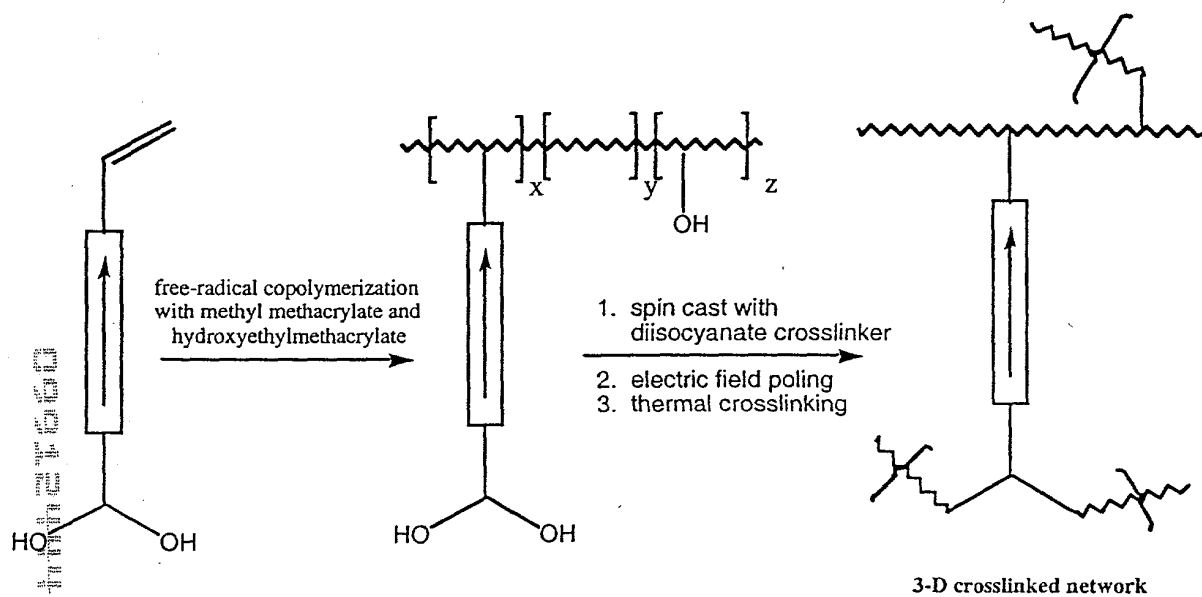


FIGURE 44

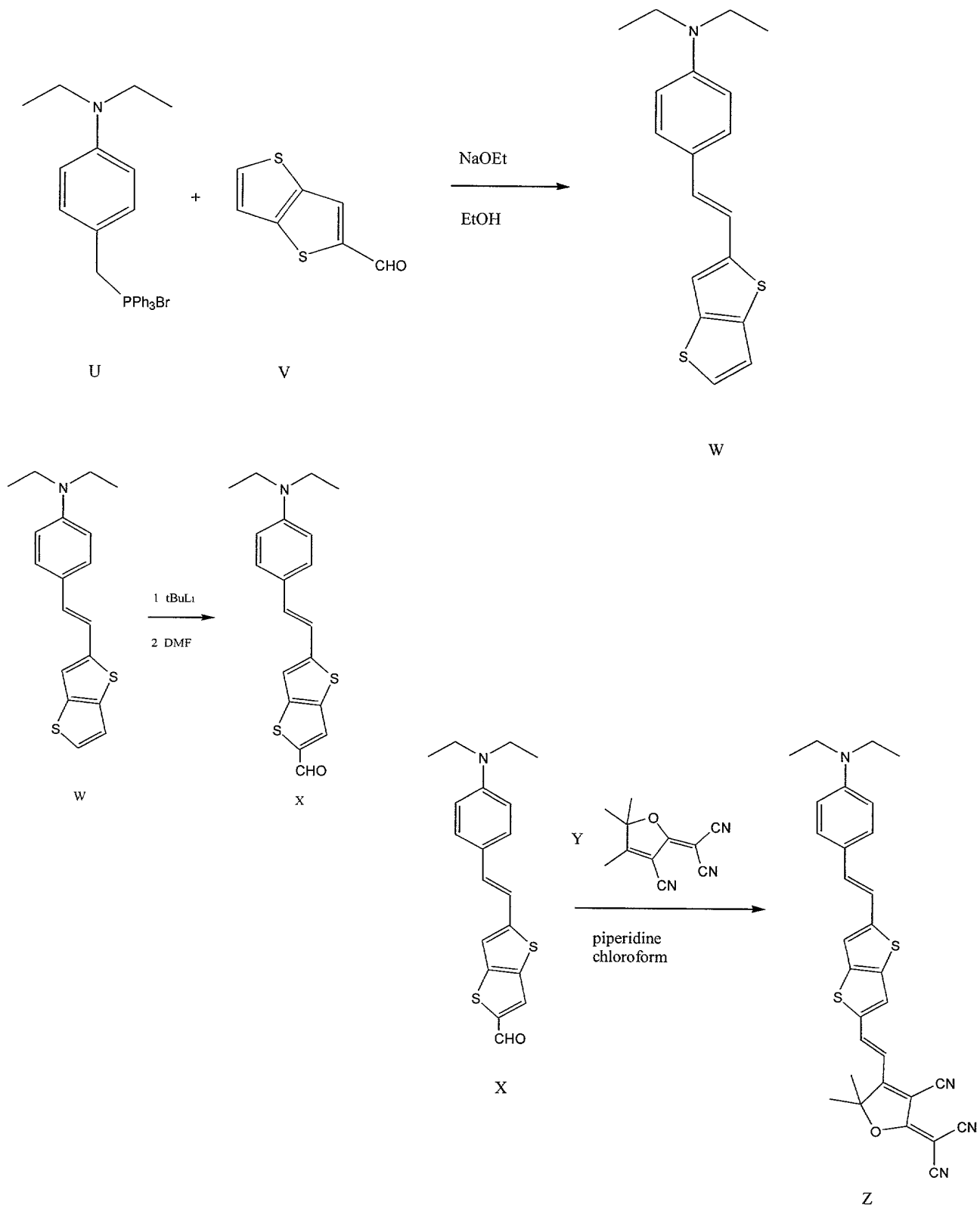
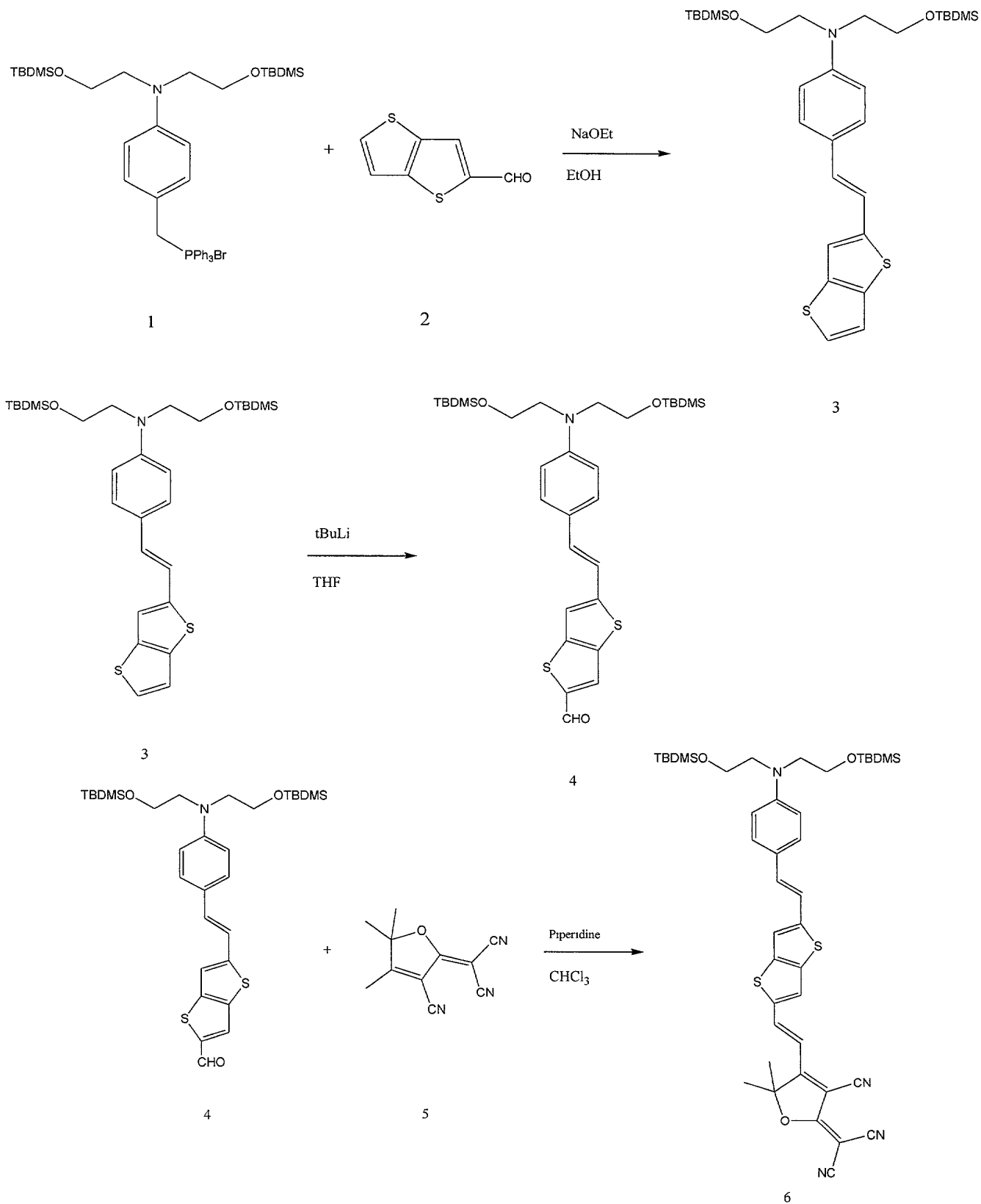
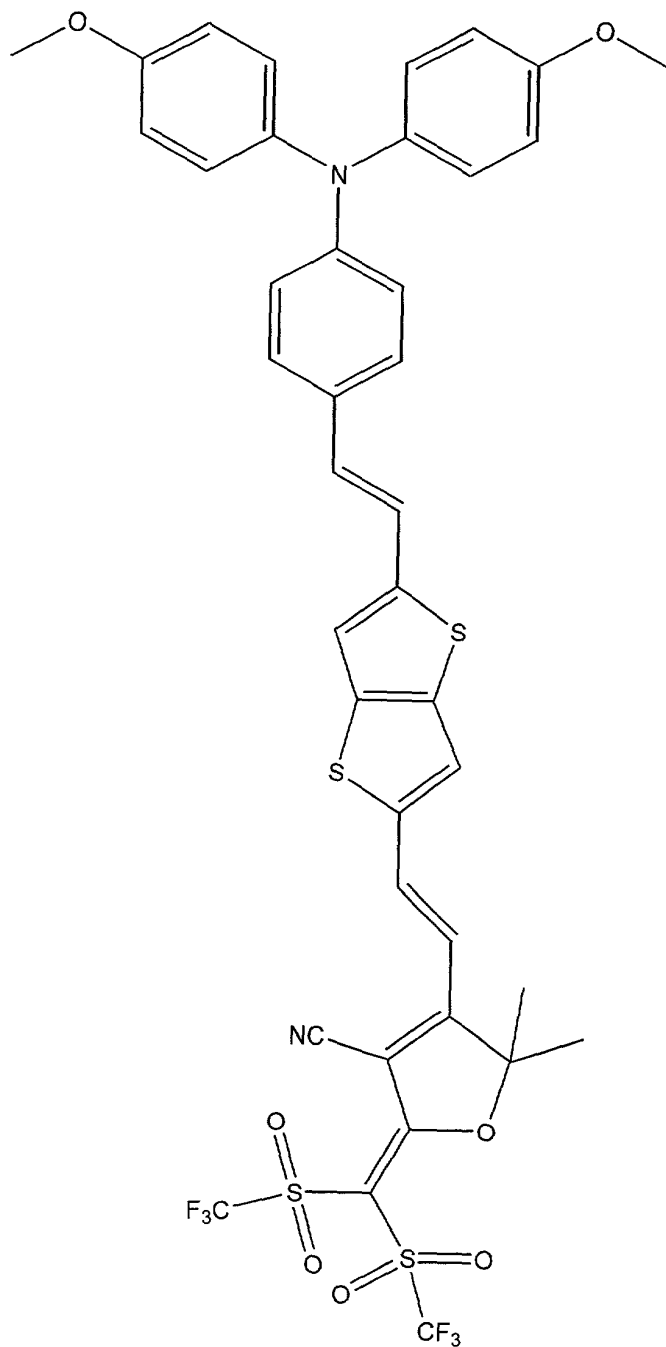


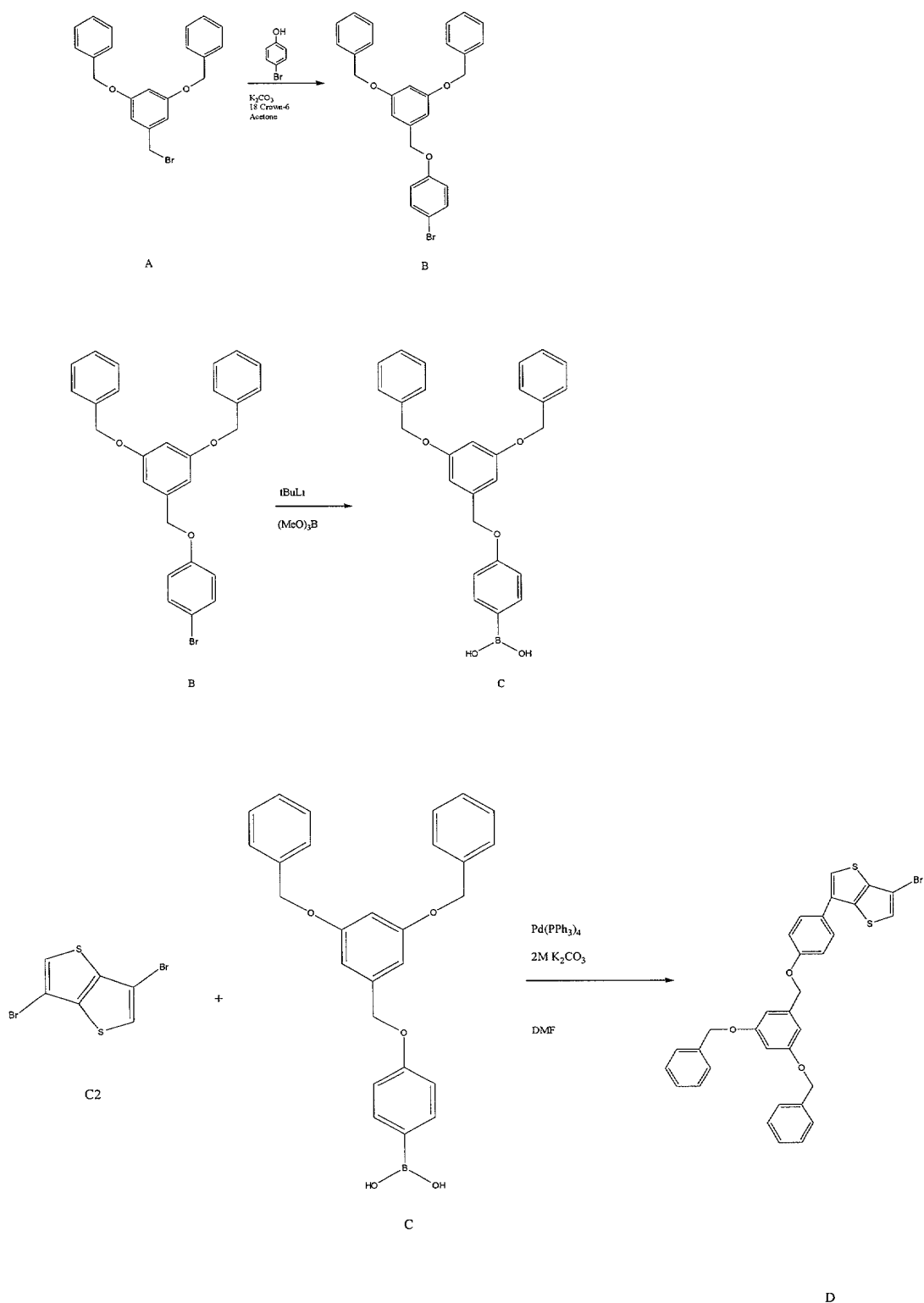
FIGURE 45



**FIGURE 46**



**FIGURE 47**



**FIGURE 48**